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**BRIEF SEMI-ANNUAL STATUS REPORT  
JOVE NASA - FIT PROGRAM  
MICROGRAVITY and AERONOMY PROJECTS**

*James D. Patterson*

Dr. James D. Patterson, Head  
Physics & Space Sciences, P.I.

*James G. Mantovani*

Dr. James G. Mantovani  
Microgravity Lab: Part I

*Hamid K. Rassoul*

Dr. Hamid K. Rassoul  
Aeronomy Lab: Part II

**PERIOD COVERED BY THE REPORT:**

May 24, 1993 - January 24, 1994

**NAME AND ADDRESS OF GRANTEE INSTITUTION:**

Department of Physics & Space Sciences  
Florida Institute of Technology  
Melbourne, FL 32901

**GRANT NUMBER:**

NAG8-195

(Supplement No. 2)

from

Marshall Space Flight Center 35812  
Dr. N. Frank Six DS01 NASA Technical Office

25 January 1994

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(NASA-CR-195121) JOVE NASA-FIT  
PROGRAM: MICROGRAVITY AND AERONOMY  
PROJECTS Semiannual Status Report,  
24 May 1993 - 24 Jan. 1994  
(Florida Inst. of Tech.) 57 p



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## SEMI-ANNUAL STATUS REPORT 1993-1994

We are now nearing the end of the three year JOVE project, so we regard this report and the following final report as somewhat historic for Florida Tech. We have had two projects active (Aeronomy under Dr. Hamid Rassoul, and Microgravity under Dr. Jim Mantovani). So far over the three years we have provided support for two undergraduates and six graduate students, of which 2 have received B.S. degrees and 3 M.S. degrees. We have published three papers, made fifteen presentations to various groups including grade and high school teachers, and we have submitted several research proposals. Four of these proposals are still pending, and the rest were not funded, but we believe we are close to achieving external support independent of JOVE. We will certainly keep trying. In addition, six more students have been trained in the JOVE program although supported by the Work Study Program. Also, we have been quite successful in both developing new courses and amending existing ones. In 1991, Florida Tech approved the creation of a doctoral program in Space Sciences. This opened an opportunity to add new graduate courses to our existing Masters program. Two new courses in Planetary Atmospheres and Magnetospheric Physics were proposed, and approved. Both courses are oriented toward the JOVE's upper atmospheric research. Dr. Rassoul taught these two courses with a total of 10 students participating in the classes (see Annual Status Report, 1991-92, Curriculum Development).

I would like to add that Drs. Mantovani and Rassoul have gained considerably in scientific stature in the last three years. Dr. Mantovani's work with the scanning tunneling electron microscope has been an outstanding help to the Department. Dr. Rassoul's work with NASA data bases in Aeronomy has tremendously helped the Department involve our students in significant space science work. It has been my pleasure to take care of some of the JOVE paperwork, and to encourage Drs. Mantovani and Rassoul to pursue their interests. I would like to thank NASA and JOVE for the financial and scientific help that they have provided our Department. After completion of this project, I look forward to future interactions, which stem from JOVE, of our project scientists with NASA.

  
-----  
Jim Patterson, Head  
Physics and Space Sciences  
Florida Institute of Technology

PART I

SCANNING TUNNELING  
MICROSCOPY LAB

*DR. JAMES MANTOVANI*

## **Part I: Scanning Tunneling Microscopy Lab**

**Dr. James G. Mantovani**

### **Summary of activities :**

- Submitted a microgravity proposal to NASA involving a study of the effects of gravity on the growth of electrodeposited thin films (status: pending).
- Submitted a proposal to the Florida Space Grant Consortium to provide summer support for undergraduates interested in using the STM to study electrodeposited thin films (status: pending).
- Received additional external non-NASA funding to support our STM research. (funding began in September 1993).
- Began initial construction of an atomic force microscope during the summer 1993.
- A high voltage circuit was constructed to increase the scanning range of the STM.
- R. Friedfeld received his M.S. degree in 1993, and is now working on his Ph.D.
- A new M.S. level graduate student, Z. Wu, has begun working for the JOVE group.
- Poster presentation at the annual JOVE meeting.
- Article on space grown crystals (non-refereed).
- Currently working on a new NASA proposal to use photoacoustic spectroscopy to complement our STM studies of mercury cadmium telluride and related crystals.

### **I. Research :**

#### Brief summary of research activities initiated since 1992-93 JOVE Annual Report:

1. In September 1993, additional research funding to support the STM Lab was obtained through the Florida Solar Energy Center (FSEC), Cape Canaveral, Florida (see Appendix A3). Our FSEC research involves studying solar cell materials using the STM which we built at Florida Tech using a portion of our initial JOVE equipment funding. One result of our participation in the FSEC project will be to design and build an STM system which is portable. Our present STM system is not easily transported to another lab, which is sometimes desirable. That system consists of the sample stage, the electronics chassis, a desktop personal computer, and the data acquisition and control hardware, of which only the sample stage is small in size. Through the new FSEC funding, we will use a portable laptop computer, an external data acquisition and control system, and a more compact electronics chassis to connect to the STM sample stage. It should be noted that this project will be of interest to NASA since we anticipate that our portable STM system could serve as a prototype STM system which might be used on the Space Shuttle during a Spacelab mission, or onboard the proposed Space Station.

2. The design and development of an atomic force microscope was begun during the summer and fall of 1993 because our crystals are alloys of mercury cadmium telluride which can vary from semi-metals to insulators in their electronic properties. The scanning tunneling microscope is only able to image the surface structure of electrically conductive crystals. By building an atomic force microscope (AFM) we will be able to image the surface structure of any sample, regardless of its conductivity.
3. A high voltage circuit was constructed to increase the scan range capability of the scanning tunneling microscope. The range of our scanning voltages is now 290 V which corresponds to a distance range of approximately one micron using our present piezoceramic tube scanner. The scan range will later be extended by purchasing another piezo tube which has different dimensions.

#### Publications:

1. Non-refereed publication: Patterson, J., S. Billings, and J. Mantovani, 1993, "Space Grown Crystals", Brevard Tech. Journal, August, 1993, v.2, pp. 23-7. (Appendix A1)
2. Non-refereed publication: Oswalt, T.D., J.H. Blatt, J. Burns, R.S. Jin, J. Mantovani, J.D. Patterson, J.B. Rafert, H.K. Rassoul, J.A. Smith, and M.A. Wood, 1993, "Department of Physics and Space Sciences Annual Report", Bulletin of the American Astronomical Society, in press. (see Appendix A2)

#### Oral and/or Poster Presentations:

1. Rassoul, H., J.G. Mantovani, and J.D. Patterson, "FIT-NASA JOVE Labs: Update", Poster Presentation, Annual JOVE meeting, Corpus Christi, Texas, summer 1993.

#### Proposals:

1. Agency Submitted to: Florida Solar Energy Center      Submitted: Sept. 1993  
 Title: Improved Efficiencies of Solar Cells Using Multilayer Materials  
 PIs: R. Raffaele, J. Mantovani, V. Burnett, and J. Patterson  
 Duration: One (academic) year      Amount: \$28,763      Status: **Started Sept. 1993**  
 (see Appendix A3)  
 Note: This funding was the Physics Dept. portion of the total funding that the University received from the proposal that the University as a whole submitted to FSEC.
2. Agency Submitted to: NASA      Submitted: June 1993  
 Title: Effects of Gravity on Electrodeposited Superlattice Solar Cells  
 Principal Investigators: R. Raffaele and J. Mantovani  
 Duration: two years      Amount: \$117,985      Status: pending  
 (see Appendix A4)
3. Agency Submitted to: Florida Space Grant Consortium      Submitted: Dec. 1993  
 Title: Electrochemically Deposited Thin Film Solar Cells  
 Principal Investigators: R. Raffaele and J. Mantovani  
 Duration: Summer 1994      Amount: \$5,000      Status: pending  
 (see Appendix A5)

## **II. Future Research Plans :**

1. A pending Microgravity Research proposal to NASA (see Appendix A4) includes an STM-based study of the effects of gravity on the growth of electrodeposited thin films. It has been shown that electrodeposition can be used to produce superlattice structures. The proposed research is intended to study a promising solar cell material, copper indium diselenide, and to use electrochemical deposition techniques to fabricate superlattice structures of this material. The object is to design and build a superlattice that is capable of absorbing more of the sun's radiation more efficiently, and to understand the role that gravity has on the growth of the individual layers. The proposed thin film electrodeposition experiments will be conducted at Florida Tech, as will be the STM investigations of the materials.
2. We are currently working on a new NASA Microgravity proposal which would involve using the technique of photoacoustic spectroscopy as a complementary surface characterization technique to our STM studies of mercury cadmium telluride and related crystals. This technique would allow us to study deep defects in these crystals in order to test theoretical models.

## **III. JOVE Students :**

Graduate students: (Two graduate students are working at the present time)

1. Robert Friedfeld successfully defended his M.S. degree in 1993 and is now working on his Ph.D. degree. (see Appendix A6)
2. Ziquang Wu is a new M.S. student who began working in the JOVE group during the Fall semester, 1993.

Undergraduate students: (None at the present time)

## **IV. Related Courses :**

No new courses were introduced.

## **V. Outreach :**

The main focus has been to make the faculty and students of other Departments on campus aware of our JOVE research efforts, and to encourage their collaboration with us on research projects which are of mutual interest. Within the Physics and Space Sciences department, we have given seminars to our freshmen on the STM research project, and have encouraged them to consider work-study assignments in our lab. Several freshmen and upper level undergrads have expressed interest, and we expect that at least one of them, a junior, will be working in the lab in the near future. Outreach has also been conducted through a collection of articles which have been provided to local area high school science teachers. Included in this collection is the article on growing crystals in space (Appendix A7).

# Space Grown Crystals

By Jim Patterson, Sandi Billings, and  
Jim Mantovani

The exploitation of space began with the launch of Sputnik in 1957, which started the race to the moon and the race for dollars. In the name of national pride, tax support was rallied not just for exploring the unknown, but also because of the promise that scientific returns will make money through the development of new products and, in the process, will raise the standard of living. Of course, space has been used for military purposes and for various benign remote sensing purposes, but the idea of manufacturing something in space is particularly attractive, promising a return on the dollar. After more than 25 years of promises, we may have found a space-based industry that will deliver.

The growing of crystals in space meets many of the criteria for space manufac-

ture. The product --- nearly defect-free crystals --- is extremely valuable, compact, and light, and made much better than on Earth. The growth of certain kinds of crystals seems to benefit from the microgravity environment of space.<sup>(1,2)</sup> The profitability of manufacturing crystals in space, however, remains an open question.

In this article we first review what crystals are and how they are grown, and then we discuss the concept of microgravity and why it might be an attractive environment for growing crystals. Before discussing the Space Station and the Space Shuttle, we will review some earlier techniques for growing crystals in microgravity. Finally, we will discuss some recent and proposed techniques for growing crystals in space.

Most people think they know what a crystal is --- after all, it's as clear as crys-

tal, isn't it? Actually, crystal glass isn't crystalline at all; it is a special kind of amorphous or random structure. A crystalline structure has a regular array of atoms, as regular as the arrangement of black and white squares on a checkerboard. This perhaps can give us a clue as to why it is difficult to grow perfect crystals on Earth under the influence of gravity.

## Crystal Defects

No crystal is perfect. Some defects may be desirable, such as the donors and acceptors introduced into semiconductors to change their electrical conductivity. Even when desirable, the number and types of

Table 1

### SOME CRYSTALS GROWN IN SPACE

CRYSTAL	USE
CdZnTe	Material Substrate for HgCdTe
HgCdTe	Infrared detection
HgZnTe	Infrared detection
GaAs (doped)	High Speed IC's and Lasers
InSb	Various electronic devices
PbSnTe	Broadband and Infrared detection
Protein	Research

The basic reason for growing all crystals in space is to produce large, defect free, homogeneous crystals.

#### About the authors:

*Dr. Jim Patterson is the head of the Department of Physics and Space Sciences at Florida Tech. He joined the university in 1984 from the South Dakota School of Mines, and he loves to go back to his gold mine there whenever possible. Jim's specialty is theoretical solid state physics, and he currently is working under a NASA grant, studying narrow gap semiconductor materials for infrared detectors.*

*Sandi Billings became a science writer after earning her bachelor's degree in space science at Florida Tech. Currently, as the director of Teaching & Research Labs at Brevard Community College, Sandi manages the laboratories being developed in Palm Bay for chemical analysis, microbiology, and remote sensing/Geographic Information Systems.*

*Dr. Jim Mantovani, assistant professor of Physics and Space Sciences, does much of his research using a scanning tunneling microscope that he built at Florida Tech. Prior to joining the university, Jim spent three years at the Oak Ridge National Laboratory. He obtained a Ph.D. in Physics from Clemson University in 1985.*



**Florida Institute of Technology  
Department of Physics and Space Sciences  
Melbourne, Florida 32901**

This report covers the period 1 January 1992 to 30 October 1993.

## **I. PERSONNEL**

J. D. Patterson serves as Department Head, and reports to the Dean of the College of Science and Liberal Arts, G. Nelson. Faculty with instructional and research activities in Space Sciences include Professors J.H. Blatt, J. Burns, T.D. Oswalt, J.D. Patterson, and J.B. Rafert; Associate Professor R.S. Jin; Assistant Professors J. Mantovani, H.K. Rassoul, M. A. Wood, and Adjunct Instructor J.A. Smith. Graduate students in Space Sciences (or in Physics and pursuing astrophysical research projects) during this report period include J. Baerman, B. Bailey, J. Barker, T. Beck, T. Bentley, D. Bub, F. Chiu, R. Duren, L. Fortier, J. Freel, S. Hathway, E. Holbert, H. Leckenby, J. Leko, M. Martinez, W. Picker, G. Sellar, S. Shufelt, J. Simpson, J. Smith, E. Sotolongo.

Full time research staff engaged in projects at or in support of the Malabar Test Facility include S. Briggs, J. Freel, E. Holbert, and B. Palmblad, and G. Sellar; all hold Research Scientist I positions. E.T. Rusk served as a Research Scientist II until 1993 when he accepted the position of Program Manager for ORION International Corporation at the Malabar Test Facility.

## **II. ACADEMIC PROGRAMS**

The Department offers complete bachelors, masters and doctoral programs in Space Sciences as well as Physics. Currently, the enrollment in Space Sciences includes 36 undergraduates and 15 graduate students, of which 5 are pursuing the Ph.D. in Space Sciences. Enrollments in Physics include 22 undergraduates and 8 graduate students, including 4 in the doctoral track.

## **III. FACILITIES AND EQUIPMENT**

The Department operates three observatory facilities: the Southeastern Association for Research in Astronomy (SARA) 0.92-m telescope at Kitt Peak National Observatory, an 0.64-m telescope at Bull Creek Wildlife Refuge in Florida, and a 0.35-

meter telescope for student projects at the Dairy Road Observatory near the Melbourne campus.

Florida Tech is the Administrative Institution of SARA, a consortium of the Florida Institute of Technology, East Tennessee State University, University of Georgia, Valdosta State University and Florida International University. SARA is recommissioning the former Kitt Peak National Observatory 0.9-m telescope as a fully-automated facility for CCD imaging and photometry at a new site on Kitt Peak. The SARA telescope is being retrofitted with a full telescope and observatory control system, clocks, precipitation and cloud sensors, four port instrument selector and small format CCD camera. Recently the first scientific instrument, a photopolarimeter, has been installed. The facility will begin operation in late 1993.

Bull Creek Observatory is located in a state of Florida forestry preserve, located 25 miles west of Melbourne in an area of low sky background. The telescope is used for photometric observations of close binary stars, asteroids, and white dwarfs. It is controlled by an AutoScope system similar to that used at the SARA observatory. Instrumentation includes a SBIG CCD camera with BVRI filters and SSP-3a solid state photometer.

The Department also has access to 1.22-m and 0.64-m telescopes at the Malabar Test Facility, an Air Force Optical Tracking Site in Palm Bay, Florida approximately 7 miles from campus. These telescopes can be configured with a wide range of visible and infrared CCD systems. The Florida Tech 0.41-meter telescope is also at Malabar, where it is used for a variety of photometric studies.

The department currently supports four Sun SparcStations, several Macs and PCs. Most are linked via ethernet to the VAX and Harris HCX-9 at Florida Tech's Academic Research Computing Services. Various software packages are available, e.g. FAIM, FLIP, IRAF, IRI, Lowtran, MSIS, SpeCal, Wilson-Devinney Model, etc.

## **IV. RESEARCH**

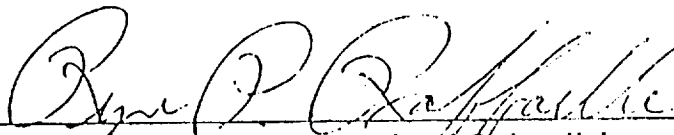
### **a. Astronomy and Astrophysics**

Oswalt and several students are continuing an NSF-sponsored study of over 500 common proper motion binaries (CPMBs) with white dwarf

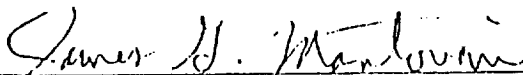
# Improved Efficiencies of Solar Cells Using Mullilayer Materials

FSEC Proposal 1993/94

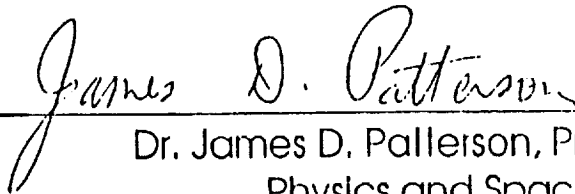
The Florida Institute of Technology  
Physics and Space Sciences Department



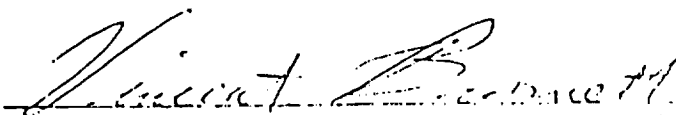
Dr. Ryne P. Raffaele, Project Scientist and Assistant Professor  
Physics and Space Sciences



Dr. James G. Manlovan, Project Scientist and Assistant Professor  
Physics and Space Sciences



Dr. James D. Patterson, Professor and Head  
Physics and Space Sciences



Dr. Vincent Burnett, Visiting Assistant Professor  
Physics and Space Sciences

September 3, 1993

Proposing Organization:  
Florida Institute of Technology  
150 W. University Blvd.  
Melbourne, FL 32901

Type of Organization:  
non-profit, private university

This Proposal is Being Submitted in Response to:  
NASA NRA-93-OSSA-12

## Effects of Gravity on Electrodeposited Superlattice Solar Cells

Ryne P. Raffaele PI

&

James G. Mantovani Co-I

Florida Institute of Technology  
Department of Physics and Space Sciences  
150 W. University Blvd.  
Melbourne, FL 32901  
(407)-768-8000 ext.8098

Date of Submission: 6 / 30 / 93

Proposed Start date: 1 / 3 / 94

Dates of Project Duration: 1 / 3 / 94 - 12 / 31 / 95

Amount of Funding Requested: \$117,985.16

Authorized Representative:

Robert A. Merrill

Date:

6/30/93

## Electrochemically Deposited Thin Film Solar Cells

Dr. Ryne P. Raffaele and Dr. James G. Mantovani  
 Department of Physics and Space Science  
 Florida Institute of Technology  
 150 W. University Blvd.  
 Melbourne, Florida 32907

Since solar energy is used to power a wide variety of spacecraft, such as communication satellites, the development of an economically feasible means of utilizing the essentially inexhaustible source of solar power is vital to the aerospace industry. Future developments in space will be tied to the means by which we use the readily available source of energy provided by the sun. In harnessing this solar energy, solar cells have generated considerable interest because they are non-polluting, have no moving parts, can be operated on almost any scale, and can be maintenance free.

Solar cells are based upon the photovoltaic effect which was discovered by E. Becquerel in 1839. The first practical cells were developed at Bell Laboratories in 1954 and made out of silicon. Since that time, photovoltaics or PV cells of GaAs have been developed which are much more efficient at converting the sun's energy. However, they are also quite expensive. The materials used to create a photovoltaic dictates its efficiency. With this in mind, we have developed an on-going research program in which we are looking for new materials, new ways of combining existing materials, and cost-effective means of synthesizing these materials.

Several high-vacuum techniques have been used to produce thin films of  $\text{CuInSe}_2$  which has emerged as the leading candidate for this application due to its ideal bandgap and optical absorption characteristics. A module based on this system has achieved efficiencies as high as 11.1%. A cost-effective method for producing  $\text{CuInSe}_2$  which does not involve high-vacuum or temperature control is electrochemical deposition. This technique, unlike its high-vacuum counterparts, is simple, inexpensive, involves negligible waste of materials, and is ideal for large scale production. Electrodeposited polycrystalline thin film photovoltaics have already been produced with efficiencies of 10%.

In this project, students will be instructed in methods of preparing suitable substrates and also in ways to electrochemically deposit semiconducting thin films based upon the  $\text{Cu}_x\text{In}_{1-x}\text{Se}_2$  system. They will experimentally determine the structure and stoichiometry of as-deposited films as a function of deposition conditions using results from x-ray diffraction (XRD), energy dispersive spectrometry (EDS) or wavelength dispersive spectrometry which is performed in a scanning electron microscope (SEM). They will also analyze the nucleation and growth of these films using in-situ electrochemical analysis. Finally, the culmination of this project will be in comparing results from optical spectroscopy (e.g., transmission and specular reflectance measurements) and electrical measurements (e.g., 4 point resistivity measurement) to their initial deposition conditions, structural and elemental results.

The goal of this work will be for the students to become familiar with many of the techniques involved in materials characterization, to understand the mechanisms and important aspects of solar cells and their use in space, and to have experimentally determined a relationship between the optical absorption and electrical characteristics of thin-film solar cell materials to the conditions by which they were synthesized.

THE CONSTRUCTION AND CALIBRATION  
OF A SCANNING TUNNELING MICROSCOPE  
USED TO IMAGE ELECTRICALLY CONDUCTIVE MATERIALS

A Thesis

Submitted to

The department of Physics and Space Sciences  
and The Graduate School of  
Florida Institute of Technology

In Partial Fulfillment  
of the requirements for the degree of

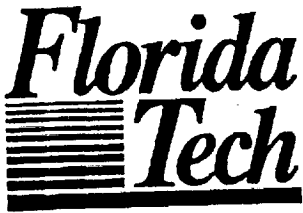
Master Of Science

Physics

by

ROBERT B. FRIEDFELD  
B.S., Seton Hall University  
January 1993

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# **SOME ASPECTS OF PHYSICS AND SPACE SCIENCES AT FLORIDA TECH**

## **Recent Articles in Brevard Technical Journal**

- 1. The Evolution of Space Science on the Space Coast**
- 2. Infrared: Light in the Dark**
- 3. SpaceGrown Crystals**
- 4. Efficient, Cost-Effective Solar Power**

# PART II

# AERONOMY LAB

*DR. HAMID RASSOUL*

## Part II: Aeronomy Lab

Dr. Hamid K. Rassoul

### Summary of activities:

- Submitted 3 proposals to NASA and the Florida Space Grant Consortium (Status: pending).
- Published 1 refereed paper in May 1993 and re-submit another refereed paper since then.
- Five aeronomy students attended the 1993 CEDAR conference in Boulder, Colorado, and one of them had a poster presentation.
- Worked with 3 undergraduate and 3 graduate students in Aeronomy lab. One graduate student completed her M.S. degree in December of 1993, and the other two are working on their thesis. Support one of the graduate students to work past summer at Huntsville, AL, working on ATLAS - ISO database.
- Taught one of our new JOVE courses, Space Physics I: Space Plasma, for the first time to five graduate students.

### I. Research

#### Publication:

- Refereed publication: Not since the JGR's paper that appeared in May issue of Journal of Geophysical Review (Rassoul et al, JGR, 98, 7695, 1993). (A copy was enclosed with the 92-93 report)
- Refereed publication: The "Sensitivity of the 6300 Å twilight airglow from McDonald Observatory to neutral composition", submitted to J. Geophys. Res., accepted but it has not been out yet (Dec 21, 1993). (A copy was enclosed with the 92-93 report). I'm working on a new paper with my graduate student and our JOVE mentor, Dr. Torr.
- Non-refereed publication: Oswalt, T.D., Blatt, J.H., Burns, J., Jin R.S., Mantovani, J., Patterson, J.D., Rafert, J.B., Rassoul, H.K., Smith J.A., Wood M.A., 1993 "Depart. of Physics and Space Sciences Annual Report", Bulletin of American Astronomical Society (B.A.A.S), in press. (see enclosure B-1)

#### Oral and/or Poster Presentations:

- Chiu F.G. (JOVE Student), H. Rassoul, and P. Richards, "Neutral Wind-HmF<sub>2</sub> Relation: parametrization of the alpha coefficient", Poster Presentation, CEDAR meeting, Boulder, CO, June 1993. (see enclosure B-2)



- Rassoul H., J.G. Mantovani, and J.D. Patterson, "FIT-NASA JOVE Labs: Update", Poster Presentation, Annual JOVE meeting, Corpus Christy, TX, summer 1993. (see enclosure B-3).
- Torr, D.G., J. Leko (JOVE Student), M.R. Torr, P. Richards, and H. Rassoul, "Modeling of the  $O(^1S)$  and  $O_2(A^3\Sigma)$  Emissions Observed by ISO", ATLAS-1 Investigator Working Group Meeting, Hunts., AL, May 1993.(see enclosure B-4)
- Leko, J. (JOVE Student), D.G. Torr, T. Chang, M. Torr, P. Richards, T. Baldrige, and H. Rassoul, "Implications of Large Variability Observed on ATLAS 1 in Mesospheric Oxygen Airglow for Atomic Oxygen", Poster presentation Fall AGU. (see enclosure B-5)
- Fanghwa (Grace) Chiu; "Thermosphere-Ionosphere Coupling : Neutral Wind to HmF2 Relation : (JOVE Student); M.S. Thesis; Florida Inst. of Technology, December 1993 (see enclosure B-6)

### Proposals Submitted:

1) Agency Submitted to: NASA Submission Date: Sep. 1993  
 Title/author: Electron Energy Fluxes at Low Latitude  
 PI: H.K. Rassoul and Co-PI: W. B. Coley ; One year, \$60K; pending . (see enclosure B-7)

2) Agency Submitted to: NASA Submission Date: Sep. 1993  
 Title/author: An Observational Test for the Low Latitude Boundary Layer  
 PI: H. K. Rassoul , One years, \$90 K, pending. (see enclosure B-8)

3) Agency Submitted to: Florida Space Grant Consortium Submission Date: Dec. 1993  
 Title/author: Atlas-1 Observations: Mesospheric Atomic Oxygen  
 PI: H.K. Rassoul, Duration:Summer 1994 Amount: \$5K Status: pending.  
 (see enclosure B-9)

4) Agency Submitted to: CEDAR-NSF Submission Date: Feb. 1993  
 This is not a proposal to support JOVE research, only travel support requests for my JOVIAN students (four graduate and one undergraduate students) to attend CEDAR meeting at Boulder, CO during summer 1993 (June 20-June 28). (see enclosure B-10 )

## **II. Brief description of research results to date on each project:** (50 words or less on each project)

### **Aeronomy:**

(a) ATLAS-1/ISO mesospheric oxygen project: A total of four different mesospheric oxygen emission codes were created this past summer. These codes calculate the intensity along the line of sight of the shuttle observations for 2972Å, Herzberg I, Herzberg II, and Chamberlain bands. The codes are presently stored in Huntsville on UAHOAL, a VAX 4000 mainframe and our computer facilities at Florida Tech . We compared the calculated profiles from these codes with the ISO's data. Major findings have been reported in three presentations and will be published in JGR. (see Mr Leko's progress report, enclosure B-11)

(b) Thermosphere-Ionosphere coupling project: The project was completed with two major accomplishments which are: (i) collection of 500 data points on modulation of neutral wind with geophysical variables; (ii) establishment of constraints on behavior of the height of the ionosphere as a result of interaction between geophysical and geometrical factors. (abstract enclosed, see enclosure B-12; also see Grace Chiu in section III for further details on this project)

(c) Magnetotail Plasma project: This project has been centered around familiarization with the subject in the form of a literature search and preprocessing of IMP-8 data. We have processed a few of the magnetopause boundary crossing and Mr. Baerman is currently working on more data. We have submitted an abstract, based on the preliminary findings to the Chapman Conference which will be held on March 14-18 in San Diego, California. (see Ms. Baerman's progress report and a copy of the abstract to Chapman Conference, enclosure B-13)

### III. JOVE Students :

Graduate: In this time period, I have worked with 4 graduate students. They have been involved on four different, but complementary, research projects. Mr. **John Leko** works on a mesospheric oxygen project (expected to graduate by May 1994) . Ms. **Jutta Baerman** studies physical and dynamical characteristics of geomagnetic tail's plasmas (expected to graduate by August 1994). Ms. **Fanghwa (Grace) Chiu** completed her project, thermosphere-ionosphere coupling, in December 1993. Her work was centered on parametrization of the upper atmosphere neutral wind and its dynamical effect on the height of the ionospheric F2 layer. The results of this work were presented to the faculty of Florida Tech in partial fulfillment of the requirements for a M.S. degree. An abstract of this thesis is enclosed and a complete copy of the work will be sent to USRA with our final report. The fourth graduate student is Ms. **Maria Martinez**, a PhD student in our Space Science/Astronomy division. I am assisting her in writing a proposal to undertake an analysis of observational data on low-latitude auroras by utilizing a large collection of spectrophotometric sky data obtained in the course of routine stellar spectroscopy (this data is normally tossed away by astronomers during the reduction and analysis of stellar spectra). This astronomical data provides a largely untapped wealth of excellent quality sky spectra which will complement our airglow observational database.

Undergraduate : I had 3 undergraduate students in the JOVE- Aeronomy lab . Mr. **Craig Coleman** (a Senior student) worked with John Leko on the ATLAS-1 database. Craig presented a talk at the 7th NCUR meeting at Salt Lake City, Utah, last March and submitted a paper that which appeared in the the conference proceedings. Mr. **Paul Douglas** (a Junior student) assisted Jutta Baerman on a magnetospheric project. Mr. **Jeremy Wernow** (a Senior student) recently joined our group, and he was trained by Grace Chiu to work on our thermosphere-ionosphere project. He will continue Grace's work in the Spring semester (Grace is expecting a baby). If USRA provides financial assistance as they did last year, I intend to send all my undergraduate students to the upcoming NCUR meeting.

### IV. Related Courses :

We offered Space Physics I: Space Plasma (SPS 5020) during Fall semester to our M.S. and PhD graduate students (syllabus enclosed, enclosure B-14). This course, was developed and taught by Dr. Rassoul, and was oriented toward the JOVE's upper atmospheric research (see 1991 annual report). Five graduate students completed the course. Physics of the Atmosphere (SPS 4030), one of our amended courses, was scheduled to be offered to our undergraduate students in the Spring of 1994, but was replaced by Geophysics (SPS 3010) due to the fact that the majority of our students took Physics of the Atmosphere last Spring.

### V. Outreach:

No outreach activity other than the use of our resources by students has occurred in this time period, but our department will sponsor the 1994 Physics Olympics again this year. Jovian faculty and students will provide assistance in judging as well as organizing the event (whether they like it or not). We plan to assist the upcoming Science Fair committee in judging during the Spring.

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**Florida Institute of Technology**  
**Department of Physics and Space Sciences**  
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This report covers the period 1 January 1992 to 30 October 1993.

## **I. PERSONNEL**

J. D. Patterson serves as Department Head, and reports to the Dean of the College of Science and Liberal Arts, G. Nelson. Faculty with instructional and research activities in Space Sciences include Professors J.H. Blatt, J. Burns, T.D. Oswalt, J.D. Patterson, and J.B. Rafert; Associate Professor R.S. Jin; Assistant Professors J. Mantovani, H.K. Rassoul, M. A. Wood, and Adjunct Instructor J.A. Smith. Graduate students in Space Sciences (or in Physics and pursuing astrophysical research projects) during this report period include J. Baerman, B. Bailey, J. Barker, T. Beck, T. Bentley, D. Bubb, F. Chiu, R. Duren, L. Fortier, J. Freel, S. Hathway, E. Holbert, H. Leckenby, J. Leko, M. Martinez, W. Picker, G. Sellar, S. Shufelt, J. Simpson, J. Smith, E. Sotolongo.

Full time research staff engaged in projects at or in support of the Malabar Test Facility include S. Briggs, J. Freel, E. Holbert, and B. Palmblad, and G. Sellar; all hold Research Scientist I positions. E.T. Rusk served as a Research Scientist II until 1993 when he accepted the position of Program Manager for ORION International Corporation at the Malabar Test Facility.

## **II. ACADEMIC PROGRAMS**

The Department offers complete bachelors, masters and doctoral programs in Space Sciences as well as Physics. Currently, the enrollment in Space Sciences includes 36 undergraduates and 15 graduate students, of which 5 are pursuing the Ph.D. in Space Sciences. Enrollments in Physics include 22 undergraduates and 8 graduate students, including 4 in the doctoral track.

## **III. FACILITIES AND EQUIPMENT**

The Department operates three observatory facilities: the Southeastern Association for Research in Astronomy (SARA) 0.92-m telescope at Kitt Peak National Observatory, an 0.64-m telescope at Bull Creek Wildlife Refuge in Florida, and a 0.35-

meter telescope for student projects at the Dairy Road Observatory near the Melbourne campus.

Florida Tech is the Administrative Institution of SARA, a consortium of the Florida Institute of Technology, East Tennessee State University, University of Georgia, Valdosta State University and Florida International University. SARA is recommissioning the former Kitt Peak National Observatory 0.9-m telescope as a fully-automated facility for CCD imaging and photometry at a new site on Kitt Peak. The SARA telescope is being retrofitted with a full telescope and observatory control system, clocks, precipitation and cloud sensors, four port instrument selector and small format CCD camera. Recently the first scientific instrument, a photopolarimeter, has been installed. The facility will begin operation in late 1993.

Bull Creek Observatory is located in a state of Florida forestry preserve, located 25 miles west of Melbourne in an area of low sky background. The telescope is used for photometric observations of close binary stars, asteroids, and white dwarfs. It is controlled by an AutoScope system similar to that used at the SARA observatory. Instrumentation includes a SBIG CCD camera with BVRI filters and SSP-3a solid state photometer.

The Department also has access to 1.22-m and 0.64-m telescopes at the Malabar Test Facility, an Air Force Optical Tracking Site in Palm Bay, Florida approximately 7 miles from campus. These telescopes can be configured with a wide range of visible and infrared CCD systems. The Florida Tech 0.41-meter telescope is also at Malabar, where it is used for a variety of photometric studies.

The department currently supports four Sun SparcStations, several Macs and PCs. Most are linked via ethernet to the VAX and Harris HCX-9 at Florida Tech's Academic Research Computing Services. Various software packages are available, e.g. FAIM, FLIP, IRAF, IRI, Lowtran, MSIS, SpeCal, Wilson-Devinney Model, etc.

## **IV. RESEARCH**

### **a. Astronomy and Astrophysics**

Oswalt and several students are continuing an NSF-sponsored study of over 500 common proper motion binaries (CPMBs) with white dwarf

(WD) components. The project seeks to extend the low-luminosity ends of both the WD cooling track and main sequence for wide binary systems. The sample is one of the deepest spectroscopic surveys of its type, and sets constraints on the age of the Galactic disk from the terminus of the WD cooling sequence. The kinematics of CPMBs and gravitational redshifts of the brighter WD components are being examined using differential observations of the radial velocities of the nondegenerate and WD components. Spectroscopy of the CPMB sample is primarily conducted with the 4.0-m telescopes at Kitt Peak and Cerro Tololo. Spectroscopic observations of several dozen of the faintest northern CPMBs also have been obtained at the BTA SAO 6-m telescope in Russia. UV spectra of several cool double WDs identified by this project were obtained with the HST.

Smith and Oswalt are determining photometric parallaxes of the coolest members of the CPMB sample using BVRI and JHK data collected with the 3.0-m NASA-IRTF and 3.8-m UKIRT at Mauna Kea Observatory, the 1.8-m at Lowell Observatory, the 1.3-m at Kitt Peak, the 0.6-m, 0.9-m, 1.5-m and 4-m telescopes at Cerro Tololo and the 0.9-m and 2.1-m at McDonald Observatory. Together with SK Leggett (U H-Hilo) they are developing a sequence of faint infrared stellar standards for use with large aperture telescopes. Smith received a NASA Graduate Researcher fellowship for this dissertation work, and presented preliminary results at the June 1993 AAS meeting.

This past year M. Kaplan, S. Shufelt, A. Simon and D. Strunk (all undergraduate space science majors) participated as research assistants in the CPMB project. Simon and Shufelt presented a paper on their research at the January 1993 AAS meeting. T. Beck, J. Barker, and M. Martinez completed M.S. theses related to the CPMB project in June 1993. Beck and Barker presented their results at the June 1993 AAS meeting. B.J. Smith, supervised by Oswalt and G. Howell, completed an M.S. thesis in Applied Math on the use of non-parametric statistical methods to study CPMBs.

Rafert continues research on close binary star systems, including light curve modeling of CN And, V367 Cyg, W Ser, V505 Sgr, and U Cep. Observations of the entire class of the W Serpentis stars are planned as soon as the SARA telescope is fully operational. Leckenby and Rafert are using the Bull Creek 0.64-meter telescope to obtain BVRI observations of GR Tau, ZZ Eri, V641 Ori, HM Mon, V677 Cen, AS Ser, HT Aps, V633 Sco, MT Her, IP Lyr, BS Vul and DM Del. Rafert has also obtained visible hyperspectral observations of CN And using the Starfire 1.5-meter telescope. Bentley

and Rafert are planning to use BCO for monitoring CVs in the quiescent state to examine super-hump periodicity.

Wood has received NSF funding to continue his research in theoretical and observational studies of the oldest stars in the Galaxy, the white dwarf stars. These stars, which are the remnants of some 99% of all stars formed, are stellar embers which slowly cool with age. Cooling slowly enough that even those formed from the first generation of stars in the Galaxy are still visible, the white dwarf stars are ideal tracers of the Galactic age and star-formation history. Wood has found that the local disk of the Galaxy is younger than the typical ages quoted for the central bulge and orbiting globular clusters, consistent with the idea that galaxies like our own form over a period of a few billion years, and not all at once as had previously been thought.

Wood also continues his collaboration with the Whole Earth Telescope (WET) network of observers, and is a regular observer at the U. Hawaii 0.6-m telescope on Mauna Kea. This work has resulted in a fundamental improvement in our understanding of the pulsating white dwarf stars and interacting binary white dwarf stars.

Wood and Simpson, who recently received a grant of C90 time from the Pittsburgh Supercomputing Center, are developing a code to explore the time evolution of accretion disks in close binaries using the method of Smoothed Particle Hydrodynamics (SPH). In particular, they are investigating the dynamical effects of the tidal resonances in systems with mass ratios of  $\sim 0.02$ , characteristic of the interacting binary white dwarf stars. They are transforming their results into the observational plane (e.g., luminosity versus time) for comparison with Whole Earth Telescope data. Wood and Bubb are working on a reanalysis of archival WET data from these objects, focussing on improving our physical model of these systems. Wood and Fortier are working on SPH calculations of oscillating polytropic stars with stratified density profiles, investigating non-radial oscillations and mode trapping in a full 3D hydrodynamical model.

## b. Planetary Science

Jin has continued his research in the relationship between the fluctuations of the rotation of the earth and the secular changes of the geomagnetic field using the method of maximum entropy power spectral density analysis. The objective is to improve geomagnetic prediction modeling techniques. In support of this project he received a grant from NSF/Pittsburgh Supercomputing Center and is working on "Code

## Conversion and Optimization of a two-channel Maximum Entropy Spectral Analysis Program" using the super computer Cray Y-MP.

Rassoul's research activities focus on the study of planetary atmospheric chemistry and dynamics, with emphasis on the geospace environment. This work entails ground-based optical and radar experiments as well as analysis of spaceborne optical and particle observations. Current projects include: (1) Photochemistry of the earth upper atmosphere; (2) Low latitude aurorae and SAR arc formations during large magnetic storms; (3) Role of the magnetospheric Low Latitude Boundary Layer (LLBL) in the solar wind - magnetosphere interaction. Three graduate and three undergraduate students participate in these projects.

The first project entails analysis of the ATLAS-1 airglow observations by the Imaging Spectrometric Observatory (ISO). Rassoul's team worked closely with science personnel from NASA's Marshall Space Flight Center and the University of Alabama at Huntsville (UAH) in preparation for the first NASA ATLAS launch in March 1992. Selected to participate as a guest investigator monitoring ISO data from the shuttle Atlantis, Rassoul and his students spent ten days in Huntsville performing real-time data analysis from the payload as it measured optical and ultraviolet light in the earth's atmosphere. His collaboration with NASA-UAH team continues in the form of a detailed analysis of the data as well as improving atmospheric models, particularly on a retrieval code for mesospheric atomic oxygen. The task involves modeling of the  $O(^1S)$  green line and extracting the ISO's relevant airglow observations.

The second project uses optical, plasma, and magnetic observations to investigate the characteristics of auroral emissions and particle precipitation in low latitude aurorae. Rassoul's research in the past ten years has identified the importance of local energy deposition and ionization production in relation to the chemistry and dynamic of the earth's upper atmosphere during large magnetic storms. Current research projects are thermosphere-ionosphere coupling during large magnetic storms and variation of ionospheric height ( $H_{m2}$ ) due to changes in the earth's upper atmospheric neutral wind.

The third project, still in infancy stage, utilizes existing magnetospheric databases on fields and plasmas to study solar wind-magnetosphere interaction. Analysis of IMP-8 and ISEE-3 satellite observations are used to investigate physical and dynamical characteristics of the LLBL and its role in the solar wind-magnetosphere interaction. The study may provide a critical test of the two leading

theories on solar wind-magnetospheric interaction: magnetic reconnection and viscous interaction.

Smith and Oswalt collaborate on a long term photometric project to derive rotational light curves and taxonomic types for poorly observed minor planets that are potential stellar occultation targets.

## c. Instrumentation

Blatt continues his work on Moiré Profilometry on structures and has developed an optical non-contact method to measure the shape of a surface or to compare its shape to a finished shape. The technique has applications to robot assembly and space alignment, ranging and docking and automated assembly. Under support from an NSF grant for the Cray YM-P at the Pittsburgh Super Computer Center, he is also conducting research on neural net processed machine vision systems. He is developing a real time optical processor to produce spectra of an image with military, industrial and pollution control applications and neural-net processed images of damaged structures. Blatt has recently received an NIH grant to study applications of Moiré Profilometry to reconstructive surgery.

Rafert, Holbert, collaborators at the Phillips Laboratory and four graduate students have designed, built and utilized a number of visible hyperspectral imaging spectrometers for astronomical and remote sensing applications. These instruments are capable of obtaining  $\sim 10^2$ - $10^3$  spectral channels for  $\sim 10^2$ - $10^3$  spatial channels simultaneously. Rafert, Sellar and Blatt have explored design modifications which would allow for the simultaneous acquisition of two spatial and one spectral dimensions with a single sensor element. The visible instruments which have been built thus far were used to obtain spectral signatures for a wide morphological and taxonomic range of earth satellites, using the 0.64-m telescope at the Malabar Test Facility and the 1.5-meter telescope at the Starfire Optical Range in Albuquerque, New Mexico. Observations of booster exhaust plumes for vehicles launched from the Kennedy Space Center have also been obtained at the Malabar Test Facility. This project has been supported by DARPA, ONR, and the Air Force Phillips Laboratory.

Rafert is currently working on the design of an infrared hyperspectral imager as part of a broader collaboration with Capt. Susan Durham from the Phillips Laboratory, PL/LIMI. Main project activities include deployment of the HYperspectral SATellite (HYSAT) instrument at Malabar. HYSAT is a visible hyperspectral imager which

makes use of a Spectrasource HPC-1 camera equipped with a TI TC-251 1024x1024 CCD.

Rafert, Holbert, Rusk and P. Lucey from the Planetary Geosciences Institute at the University of Hawaii have developed a sophisticated performance model for the University of Hawaii Spatially Modulated Imaging Fourier Transform Spectrometer (SMIFTS), an infrared hyperspectral imager built with support from ONR and DARPA. The code is written in C and runs on a Sparc II.

Rafert and Freel have utilized the Malabar Advanced Photometric System (MAPS) to obtain high speed photometric data of booster plumes. MAPS is a two channel high speed photometric system using two Thorn-EMI-Gencom Starlight-1 photometers designed for looking a bright objects at speeds up to 3000Hz. MAPS was supported by Photon Research Associates.

## d. Space Sciences

Jin, with collaborators Burns and Gering, is continuing an NSF-funded project entitled "Improvement of Senior Lab for Physics and Space Sciences Majors by Adding Computational Physics". This project has developed a number of new senior-level experiments for undergraduate space science and physics majors.

Mantovani continues his studies of materials that are of interest to the aerospace industry. He is studying the surface microstructure of electro-optical materials and semiconducting crystals through a joint project involving NASA and Florida Tech. The materials are grown by NASA's Microgravity Science and Applications Division located at Marshall Space Flight Center in Huntsville, Alabama. The surfaces of the crystals are studied for defects that have occurred during the growth process. The investigations involve using a scanning tunneling microscope (STM) that was built at Florida Tech by Mantovani. The STM is capable of imaging the surface of electrically conductive materials at high resolution (sometimes atomic resolution) without damaging the surface. R. Friedfeld works with Mantovani on this project with the support of both NASA/JoVe and Florida Tech.

Patterson has an on-going program funded by NASA on the electron properties of narrow gap semiconductors. Assisting in this work is Weigang Li, a Post Doctoral Research Associate. Patterson and Li have done an extensive set of deep defect calculations on Mercury Cadmium Telluride (MCT) and Mercury Zinc Telluride (MZT). Both of these materials are important as infrared detectors. Defects have an important bearing on how well the materials will perform in this area.

## V. OTHER ACTIVITIES

Blatt serves as Chief Scientist for the Orion Team Site R&D contract at the U.S. Air Force Malabar Test Facility.

Jin was awarded a Senior Faculty Research Associate Fellowship by the Naval Research Lab at Stennis Space Center, MS in the summer 1992 for his work on the project of "Multi-year Stochastic Inversion of Magnetic Observatory Data".

Mantovani and Rassoul gave poster presentations on their research activities at the NASA / JOVE Annual Meetings in 1992 and 1993.

Oswalt serves as Director of the SARA Project to recommission the KPN0 0.9m telescope and as Chairman of the Board of Directors for SARA. He is a Harlow Shapley lecturer for the AAS, and served as a Bart and Priscilla Bok Award judge for the AAS and ASP at the 1992 and 1993 International Science and Engineering Fairs. He is senior Editor of the *IAPPP Communications*, and received the Florida Tech Faculty Excellence Award for Research in 1992.

Patterson serves as the administrative P.I. for the scientific work of Rassoul and Mantovani on the NASA/JoVe program, and also as administrative P.I. for the Florida Solar Energy Center sponsored work on improved efficiency of solar cells by Raffaele, Mantovani, Burnett and Neofotistos.

Rafert served as the SARA Observatory Director through September 1993, when M. Castelaz from East Tennessee State University assumed the post. Rafert continues to represent Florida Tech on the SARA Board, has been given an IPA award from the Phillips Laboratory as a Senior Scientist, and serves as Director of the Center for Space Science Research.

Rassoul has been the chairman of Florida Tech's Admission and Scholarship Committee, and a member of Faculty Senate Executive Committee. He received the Florida Tech 1991 Faculty Excellence Award in Teaching and was recognized for exceptional performance in Research by the NASA JOVE program in 1992 and 1993 for his recent publications on low latitude aurorae and storm-time magnetospheric-ionospheric electrical current systems.

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Contributors: T.D. Oswalt, J.H. Blatt, R.S. Jin, J. Mantovani, J.D. Patterson, J.B. Rafert, H.K. Rassoul, J.A. Smith, M. A. Wood

# CEDAR Posters

<u>#</u>	<u>AUTHOR(S)</u>	<u>TITLE</u>	<u>STUDENT</u> (1st Author)
A-1	S. Allen, R.A. Vincent	Gravity Waves in the Lower Atmosphere: Seasonal and Latitudinal Variations	Yes
A-2	S.M. Bailey, S.C. Solomon, T.N. Woods	Thermospheric Airglow Response to the Solar Ultraviolet Irradiance	Yes
A-3	M. K. Bierer, C. S. Deehr	Dayside Auroral Morphology and Particle Energy Boundaries As Seen From the Ground and Space	Yes
A-4	L. M. Caldwell, D. A. Krueger, C. Y. She	Depolarization Effects in High Spectral Resolution Rayleigh Mie Lidar	Yes
A-5	J. L. Chang, S. K. Avery	Preliminary Tropospheric Results from the CADRE Campaign in the Western Pacific	Yes
A-6	J. Y. Chang, M. F. Larsen, R. D. Palmer, S. Fukao, M. Yamamoto, T. Nakamura, T. Tsuda	Comparison of Spaced Antenna Drift and Doppler Beam Swinging Wind Measurements	Yes
A-7	Y. L. Chang, M. F. Larsen, R. D. Palmer, M. Yamamoto, S. Fukao, T. Tsuda, S. Kato	Imaging Doppler Interferometry Using MU Radar	Yes
A-8	H. Chen, C. Y. She	Dispersive Faraday Filter for Na Temperature Lidar Daytime Operations	Yes
A-9	Y-H. Chen, Y-H. Chu, J -K. Chao, C -H. Liu	The Observations of Sporadic E Irregularities in Equatorial Anomaly Crest Zone By Using Chung- Li VHF Radar	No
A-10	G. Chiu, H. Rassoul	Thermosphere-Ionosphere Coupling: Relation Between Neutral Wind Speed and Peak Height of F2 Layer	Yes

# **Thermosphere - Ionosphere coupling : Neutral Winds - HmF2 relation**

**Grace Chiu & H. Rassoul**

Florida Institute of Technology, Melbourne, Florida

**P.G. Richards**

The University of Alabama in Huntsville, Huntsville, Alabama

## **1. Abstract**

The measurement of upper atmospheric neutral winds is valuable in many studies of the earth's ionosphere-thermosphere. The neutral wind affects many of the observable quantities and physical processes of the ionosphere, including the density profile of the ionospheric F region and the generation/maintenance of ionospheric electric fields. Wind measurements on a global scale are difficult to make, and the existing data base is sparse, especially in the southern hemisphere [Hedin et al, 1991]. Miller [1986,1989] presented a new technique of determining meridional thermospheric winds from measurements of the height of the maximum electron density in the F2 layer (HmF2). The technique is based on the approximately linear relationship between changes of neutral wind speed ( $U$ ) and variation of the height of F2 layer ( $h \equiv \text{HmF2}$ ). The relationship can be written as  $\Delta h = \alpha \Delta U$  where  $\alpha$  is a constant for a given site at a given time. However,  $\alpha$  is expected to change (by unknown %) with latitude, season, solar activity (F10.7 dependency), and geomagnetic activity ( $A_p$  dependency). The purpose of our study is to investigate variations of  $\alpha$  with each of the above geophysical parameters. We use different sets of geophysical parameters, the Field Line Interhemispheric Plasma (FLIP) model, and the International Reference Ionosphere (IRI) model to derive  $U$  and  $h$  and calculate  $\alpha$ . We employ the Factorial Designs method to analyze the dependency of  $\alpha$  on combinations of changes. Here, a preliminary result of this investigation is presented. The main goal is to obtain an exact parametrization of  $\alpha$ , so one can study variations of the upper atmospheric winds on a global scale using the Miller's technique or a similar method.

# **Florida Institute of Technology**

## **NASA JOVE**

### **Aeronomy Lab:**

#### **Three Regions under Investigation**

- 1) Mesosphere
- 2) Thermosphere - Ionosphere
- 3) Magnetosphere

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MODELING OF  $O(^1S)$  AND  $O_2(A^3\Sigma)$  EMISSIONS  
OBSERVED ON ATLAS 1

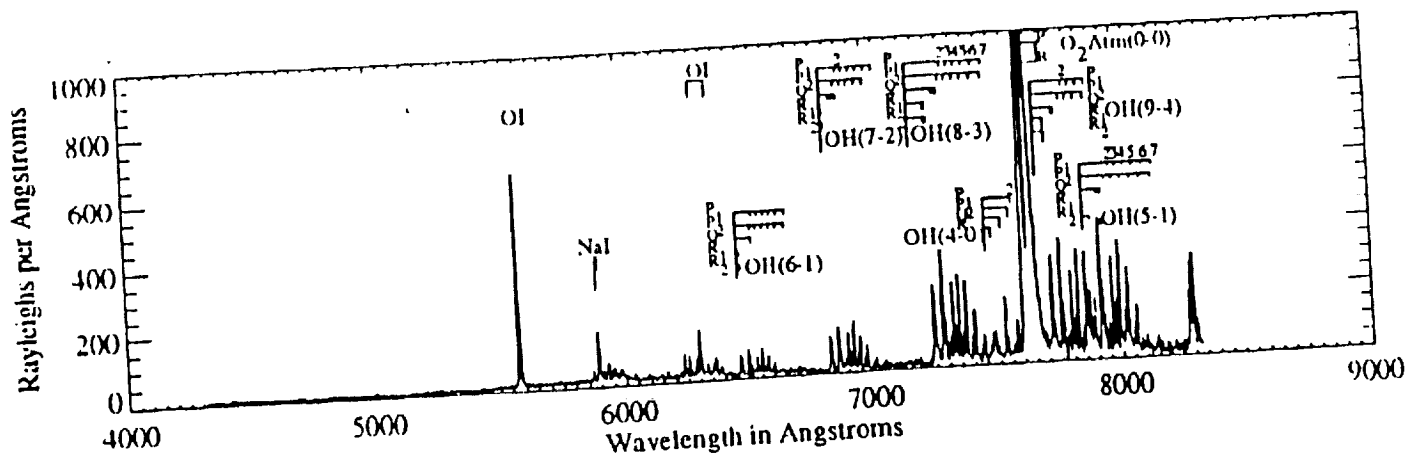
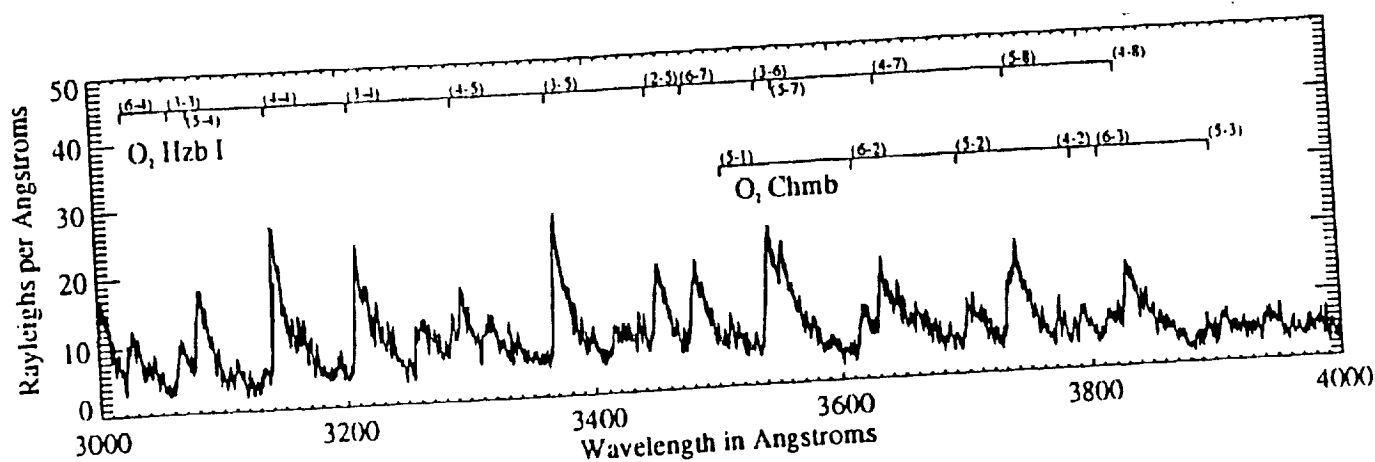
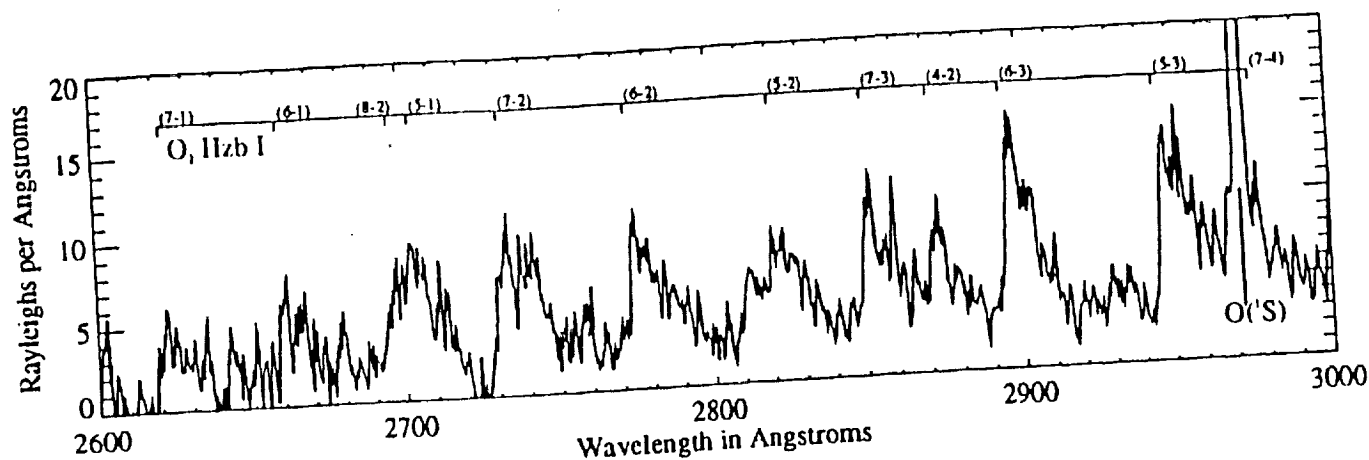
BY:

D. G. TORR, J. LEKO, M. R. TORR, J. K. OWENS,  
T. CHANG, J. A. FENNELLY, P. G. RICHARDS  
AND THE ISO TEAM

PRESENTED AT THE ATLAS 1 INVESTIGATOR  
WORKING GROUP MEETING

HUNTSVILLE, ALABAMA

MAY 11, 1993



Spectral images of mesospheric nightglow over New Guinea measured by the ISO on ATLAS 1 at ~ GMT 18:05 on day 88, 1992 at a tangent ray height of ~ 90 km. The spectrum was acquired over a latitudinal range of ~ 8°, within a 2 minute interval. The integration time per grating step was 12 seconds. (Note: The structure is not noise.)

Implications of Large Variability Observed on ATLAS 1 in  
Mesospheric Oxygen Airglow for Atomic Oxygen

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of Technology, Melbourne, Florida 32901, 407-768-8000)

The Imaging Spectrometric Observatory (ISO) acquired a unique  
database on the ATLAS 1 shuttle mission of the emissions that arise  
from the three-body recombination of atomic oxygen. Measurements  
were made between ~ 70 to ~ 110 km altitude at 2 km resolution  
during the day and night in the Spring of 1992. In this paper we  
report the results of a comparison of model calculations with ISO  
intensity measurements of the Herzberg I, Chamberlain bands, and the  
O(<sup>1</sup>S) 557.7 or 297.2 nm feature as a function of tangent ray height .  
During the nine-day ATLAS 1 mission the peak emission heights  
varied between 81 and 98 km, indicating strong dynamical control of  
the region. Based on our model results we argue that the large  
excursions in layer height are indicative of similar excursions in the  
peak height of the atomic oxygen layer. A progress report will be  
given on the development of an algorithm for retrieving O from the  
oxygen emissions.

1. 1993 Fall AGU Meeting
2. 01176107
3. (a) The University of  
Alabama In Huntsville,  
Optics Building, Room 300  
Huntsville, Alabama 35899  
(b) 205-895-6118  
(c) 205-895-6717
4. SA
5. (a) N/A  
(b) 0310 Airglow and auror  
0350 Pressure, density,  
and temperature  
0340 Middle atmosphere  
composition and chemistry
6. N/A
7. None
8. Invoice \$60 to Attached  
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10. None
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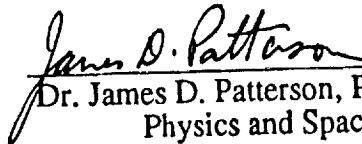
# Thermosphere - Ionosphere Coupling : Neutral Wind to hmF<sub>2</sub> Relation

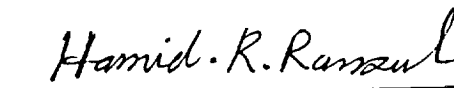
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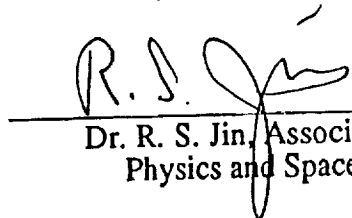
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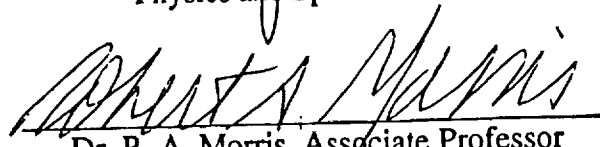
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December 1993

<b>PROPOSAL/PROGRESS REPORT RECEIPT</b>		<b>9/16/93</b>
Proposal Number	Principal Investigator:	
NRA-93-SSI-SR&T-084	Dr. Hamid Rassoul	
Proposal Received	Institution	
NASA/Code SS	Florida Institute of Technology	
Proposal/Progress Report Title		
Electron Energy Fluxes at Low Latitudes		
 Dr. Hamid Rassoul Florida Institute of Technology 150 West University Boulevard Melbourne, FL 32901-6988		

<b>PROPOSAL/PROGRESS REPORT RECEIPT</b>		<b>9 / 1 6 / 9 3</b>
Proposal Number <b>NRA-93-SSM-SR&amp;T-097</b>	Principal Investigator: <b>Dr. Hamid Rassoul</b>	
Proposal Received <b>NASA/Code SS</b>	Institution <b>Florida Institute of Technology</b>	
Proposal/Progress Report Title <b>An Observational Test for the Low Latitude Boundary Layer</b>		
<b>Dr. Hamid Rassoul</b> <b>Florida Institute of Technology</b> <b>150 West University Boulevard</b> <b>Melbourne, FL 32901-6988</b>		

# FLORIDA SPACE GRANT CONSORTIUM

Appendix B-9  
(2 Pages)

## UNDERGRADUATE SPACE RESEARCH PROGRAM

### PROPOSED SUMMER 1994 RESEARCH PROJECTS IN

SPACE SCIENCES - *see below*  
COMPUTER, ELECTRICAL & SYSTEMS ENGINEERING - *see page 2*  
AEROSPACE & MECHANICAL ENGINEERING - *see page 3*

[For application information see program announcement, contact mentor, or FSGC 904-392-6750]

#### SPACE SCIENCES

S01	Atlas-1 Observations Mesospheric Atomic Oxygen	Hamid K. Rassoul	FIT ✓
S02	Effect of the Impact of Comet Shoemaker-Levy 9 with Jupiter upon the Radio Emission from the Planet	Thomas D. Carr	UF
S03	Electrochemically Deposited Thin Film Solar Cells	Ryne Raffaele, James Mantovani	FIT
S04	The Growth of Device Quality Thin Films by Laser Ablation	Robin Kennedy	FAMU
S05	The Influence of Surfactants on the Bubble Motion in a Confined Geometry	Chang-Won Park	UF
S06	Magneto Strictive Sensors and Damping Devices Made from Laves Phase Materials by the Technique of Laser Ablations	Robin Kennedy	FAMU
S07	Observations of Comets & Asteroids	Humberto Campins	UF
S08	Orbits and Instabilities	Christopher Hunter	FSU
S09	Processing Satellite Freeze Images of Peninsular Florida	J. David Martsolf	UF
S10	Search for Possible Carriers of the Unidentified Infrared Emission Bands from Interstellar Space	Martin Vala	UF
S11	System Integration of an Ultra High Vacuum Chamber for the Growth of Multilayer Thin Films by Laser Ablation	Robin Kennedy	FAMU
S12	A Thin Film Thermoelectric Bolometer and Peltier Cooler	Robin Kennedy	FAMU

## ATLAS-1 OBSERVATIONS: Mesospheric Atomic Oxygen

Dr. Hamid K. Rassoul  
Department of Physics and Space Science  
Florida Institute of Technology  
150 W. University Blvd.  
Melbourne, Florida 32907

Atomic oxygen plays a fundamental role in the photochemistry of the mesosphere, a region of the earth's atmosphere ranges from 70 to 120 km high which exhibits remarkable photochemical-dynamical coupling. The three-body reaction of O with O<sub>2</sub> is the sole source of mesospheric ozone which plays an important role in determining the thermal structure, climatology and weather of the region. Atomic oxygen is a key player in the catalytic destruction of ozone by odd hydrogen. However, the measurement of the concentration of mesospheric atomic oxygen has proved to be very difficult. The region is too high to be studied directly by most balloon-borne instruments and too low for in situ observations by satellites. Many in situ measurement of atomic oxygen concentration, using resonance lamps and mass spectrometer techniques on board of high altitude rockets, have yielded widely varying results which have raised doubts about the reliability of the techniques. It is likely that the mesospheric O concentration is far more dynamic than originally thought, and rocket experiments which provide only isolated snapshot views are not suitable for studying mesospheric atomic oxygen.

The Shuttle/Spacelab facilities have given scientists an excellent platform for passive atmospheric observations. Florida Tech is collaborating with NASA-MSFC scientists to study airglow observations by the Imaging Spectrometric Observatory (ISO) that flew on the ATLAS-1 mission between March 24 and April 2, 1992. From these light emissions one can retrieve the composition, density, and temperature of the various layers of the upper atmosphere including mesosphere. The ISO obtained excellent measurements of the O(<sup>1</sup>S) 5577 Å line feature. Because of the quality of the measurements, we selected the O(<sup>1</sup>S) as a prime candidate for retrieving O density profiles. Eventually this can be extended to include a climatic analysis of the atomic oxygen.

In this project, undergraduate students will be trained to assist our group for airglow data processing. They will work with several software packages, including SpeCal, our processing software for the ISO spectral data, IRI-90 model, a semi-empirical ionospheric model, and MSIS-86/90 models, neutral atmospheric models. The study entails intensity extraction of O(<sup>1</sup>S) airglow emissions from overlying backgrounds and comparison of the observed values with the calculated intensities which can be obtained from the above models. The students working on this research will have opportunity to learn about the analysis of space physics data and the preparation of research results for publication.

# Jovians at Large in Boulder, Colorado

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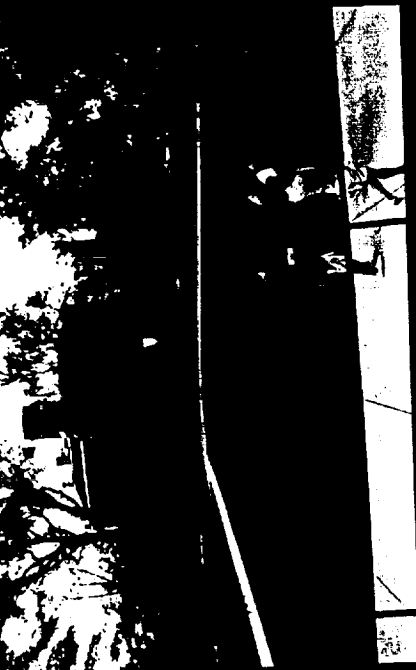
Recently, the students from the NASA/FIT/JOVE Lab attended the CEDAR conference in Boulder, Colorado. This conference brings together undergraduate, graduate, and Ph.D. students along with post docs and some of the leading scientists in the field of upper atmospheric physics. In attendance from F.I.T. were Jutta Baerman (graduate student in Physics), Grace Chiu (graduate student in Space Sciences), Craig Coleman (undergraduate student in Space Sciences), J. Leko (graduate student in Space Sciences), and Mayra Martinez (Ph.D. student in Space Sciences). Steve Hathway, a graduate from the F.I.T. Space Sciences masters program, was also in attendance with his fellow graduate students from the University of Michigan where he is pursuing his Ph.D.

Tutorial lectures, project reports, and workshops dominated the conference, but there was still some time for vacationing. Below are some of the lighter moments from this trip.

University of Colorado at Boulder  
Jovians on the loose at the campus.



University of Colorado at Boulder  
A view from outside the student union on the campus.



## MEMORANDUM

TO: Dr. H.K. Rassoul, Dr. D.G. Torr  
FROM: J.  
SUBJECT: Summer progress report  
DATE: 21 September 1993

---

Attached to this memo is a copy of my progress report for the Summer 1993 quarter. The text attempts to convey the highlights of this period and the findings which resulted. I have written this report for an audience familiar with the background of this project, thus reducing the verbiage necessary to inform a beginner. Any comments or corrections would be greatly appreciated as I am planning to use parts of this report in my thesis.



## 0. Introduction

### I. The general picture

- A. Explanation of model
- B. SPMA and PATH modifications
- C. Rate constants
- D. Atomic oxygen concentration

### II. To do

- A. Attempt to fit a high altitude, wide profile
- B. Complete addition of vibration levels in molecular species
- C. Test A and A' states as the source of  $O(^1S)$

### III. Publications and presentations resulting from this work

### IV. The chronological picture

- A. Week 1 - the creation of the model code
- B. Week 2 - using old values for TRH, managed to match the intensity profile nearly exactly
  - updated TRH using SPMA
  - in an attempted to fit the intensity profile, [O] was moved downward
- C. Weeks 3 & 4 - attempted to fit intensity profile by adjusting rate coefficients
  - Dr. Torr claims that the intensity profile matches although the bottom of the data curve cannot be reproduced
- D. Week 5 - modeling of the Herzberg I system emission to validate the movement of the [O] layer
- E. Week 6 - modeling of the Herzberg II system emission for comparison to the 2972 and Herzberg I system emissions
  - modeling of the Chamberlain system emission
  - replacement of the SPMA information by the PATH data in the 2972 model
- F. Week 7 - modification of the Chamberlain and Herzberg II models
  - began addition of vibrational levels to the Herzberg II model
  - trained Dr. Torr on the operation and logic behind the various models

## Introduction

A total of four different model codes were created during the seven week time period spent in Huntsville. These codes calculate the intensity along the line of sight for 2972Å, Herzberg I, Herzberg II, and Chamberlain bands. The codes are presently stored in Huntsville on UAHOAL, a VAX 4000 mainframe.

In this study, we analyze the feature at 2972Å versus 5577Å simply because we have an excellent set of data for this feature as well as coincident measurements of the Herzberg I, II, and Chamberlain molecular bands. The ratio of intensities of 5577 to 2972 is known to be about 40:1. Both of these features originate from the  $^1S$  level of atomic oxygen; 5577Å falls to the  $^1D$  state and 2972Å ends at the ground ( $^3P$ ) state, see figure 1.

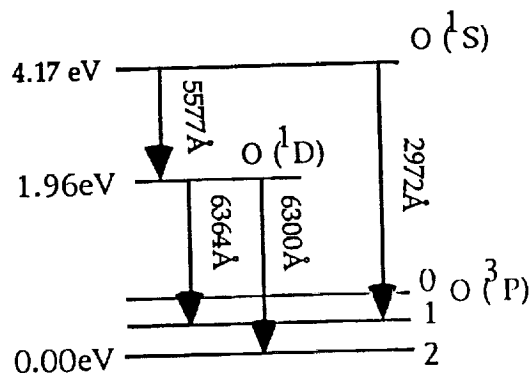


Figure 1 The atomic oxygen energy level diagram. Adapted from J.K. Hargreaves, The Solar-Terrestrial Environment, 1992.

## Explanation of model

There have been two previous versions of this program. The first calculated the intensity of an atmospheric layer using a ground based geometry. The second code used the same chemistry scheme as the former version in a space based, downward looking configuration. The third, current code corrects problems experienced with code two during the Spring quarter of 1993. It contains completely rewritten input/output (I/O), geometry, and intensity calculation routines.

The model operates in the following fashion:

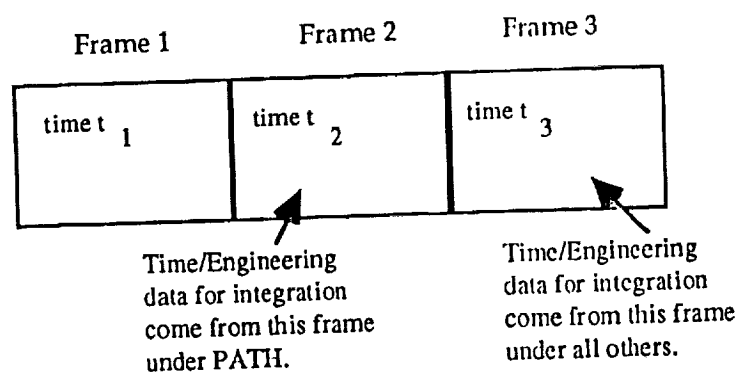
1. The user is asked to enter; the file name which contains the parameters necessary to calculate the line of sight of the instrument, whether the information is to be updated from the SPMA/PATH archives, an output filename to which the results of the calculations will be written if desired, and the percentage of MSIS 90 atomic oxygen which is to be use in the intensity determination.
2. The program then opens the appropriate file/files, determines the maximum number of lines contained within that file, and reads the data, updated if requested, into arrays.

3. A line of sight of the instrument is then determined using a combination of spherical and right triangle geometry which is segmented into a number of steps according to the user's choice of step length. At these steps, the MSIS 90 O, O<sub>2</sub>, N<sub>2</sub> concentrations, and neutral temperature are obtained, and the concentration of the species of interest found.
4. With this information, the volume emission rate and intensity are calculated. The intensity values are integrated as the program proceeds down the line of sight and output in units of Rayleighs.

#### SPMA and PATH modifications

The pointing accuracy of the ATLAS - 1 mission has been one of its most troublesome aspects to date. After a detailed analysis of the POCC data tapes, it was determined that the best estimate these tapes could provide on the tangent ray height was within  $\pm 15$  km. Consequently, all of the TRH data input to the model during the Spring 92 quarter was raised by 12 km to agree with previously published estimates. To correct for this problem alternate tapes were made available by both the Goddard Space Flight Center (SPMA) and the Johnson Space Flight Center (PATH).

The SPMA and PATH information, when used in conjunction with a program by Frank Morgan, updates the pointing information tagged to the spectra in the ATLAS database. This information known as engineering data is seen in SpeCal and includes figures such as the tangent ray height, longitude, and latitude, the shuttle longitude, latitude, and altitude, the local solar zenith angle, local solar elevation angle, line of sight azimuth of the ISO, and the local standard time. Of the two revisions, PATH is believed to be the most accurate providing TRH to within  $\pm 1$  km, for the frame at the center of the integration.



**Figure 2** Illustration of a SpeCal integrated frame containing three elements ( $t_1 < t_2 < t_3$ ).

Figure 2 shows three spectra frames taken at different times. SpeCal normally uses the engineering data associated with the last frame of the integration. The PATH revision uses the information affiliated with the center, second frame rendering the integration an "average" of the three frames.

The Huntsville model, created over the summer, has been modified to take advantage of these routines. Depending upon the particular model, the original pointing information used as input is updated from either the SPMA or PATH revisions. Two of the programs, IIERZ\_1 and 2972, will allow the user to override this "SPMA/PATH update" feature and accept input from the data file directly. Eventually all of the ATLAS - 1 ISO pointing information in the database will be revised using PATH.

#### Rate constants

From the outset of this investigation, it was believed that quenching rate constants were the dominant factors in the control of the layer heights. However, after the examination conducted this summer, this opinion has changed. It is now believed that the control of the emission layer is established by the atomic oxygen profile.

It is known, however, that the magnitude of the rate constants can effect the emission layer altitude to a small degree. Rate constants control quenching of the emission layer. As the rate constant is increased, the slope of the bottom of the layer becomes steeper. This process cuts away at the peak of the emission, forcing it to migrate higher. Consider figure 3, which shows the modeled intensity of the Herzberg I band system. Notice that the O quenching rates for these four plots are identical throughout, but the O<sub>2</sub> quenching rates decrease from a high of  $1.3 \times 10^{-11}$  to a low of  $1.3 \times 10^{-14}$ . You will also note that as the O<sub>2</sub> quenching rate drops, the peak of the emission follows.

#### Atomic oxygen concentration

As mentioned above, the atomic oxygen layer is believed to control the behavior of the various emissions, i.e., Herzberg I and II systems, 5577/2972Å, Chamberlain, etc. Figure 3 shows the MSIS-90 neutral atmospheric O, O<sub>2</sub>, and N<sub>2</sub> constituents as functions of altitude. Note the O density in the upper figure peaks at 98 km, and occurs near 88 km in the lower graph. This shift is accomplished within the model code simply by calling the MSIS routine twice, obtaining the O<sub>2</sub> and N<sub>2</sub> concentrations on the first call, and again for the O density. Subtracting the desired distance from the altitude parameter on the atomic oxygen call causes the layer to be adjusted downward by the amount specified. This shift is reflected in the intensity versus altitude profiles, figures 4 and 5.

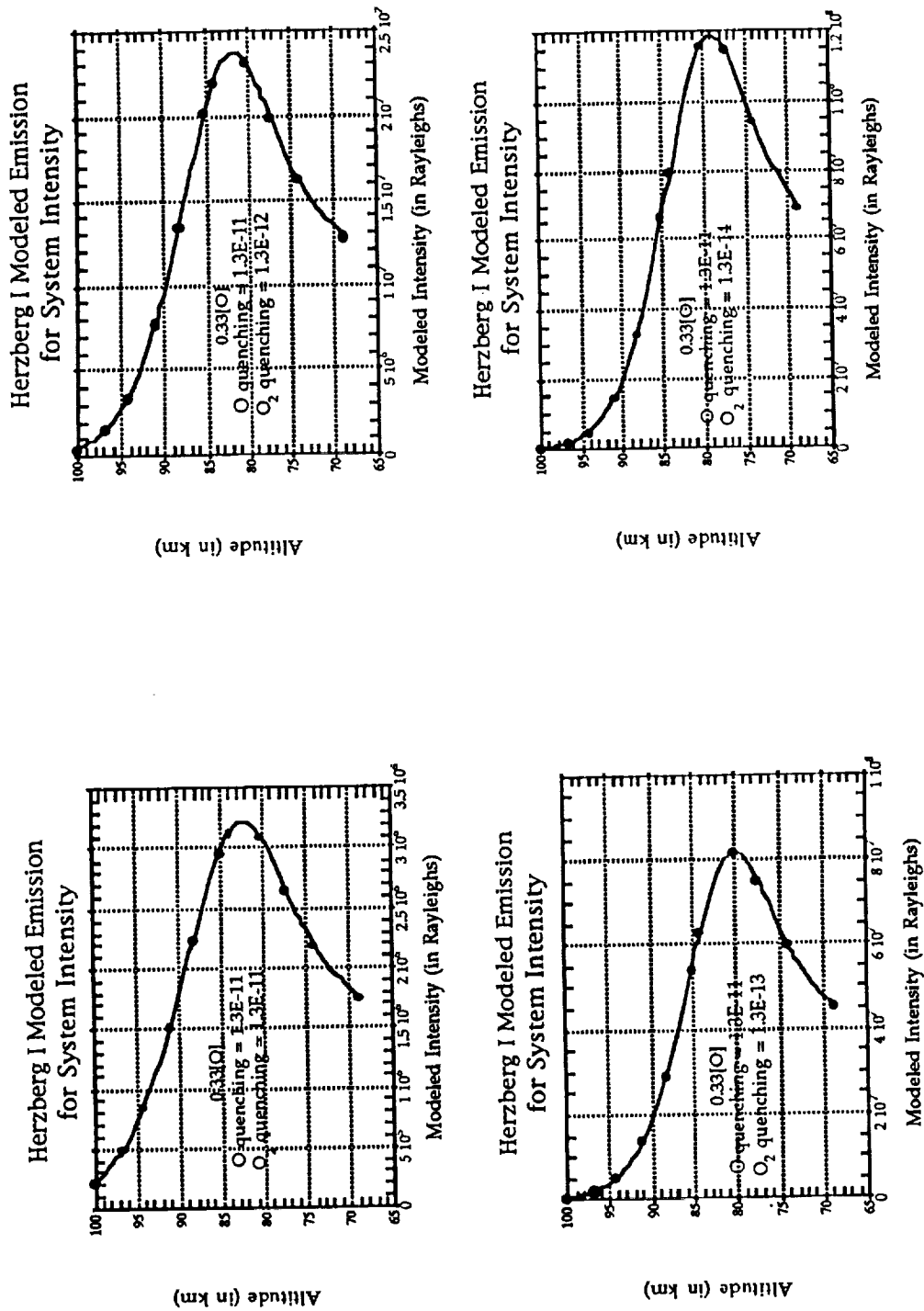
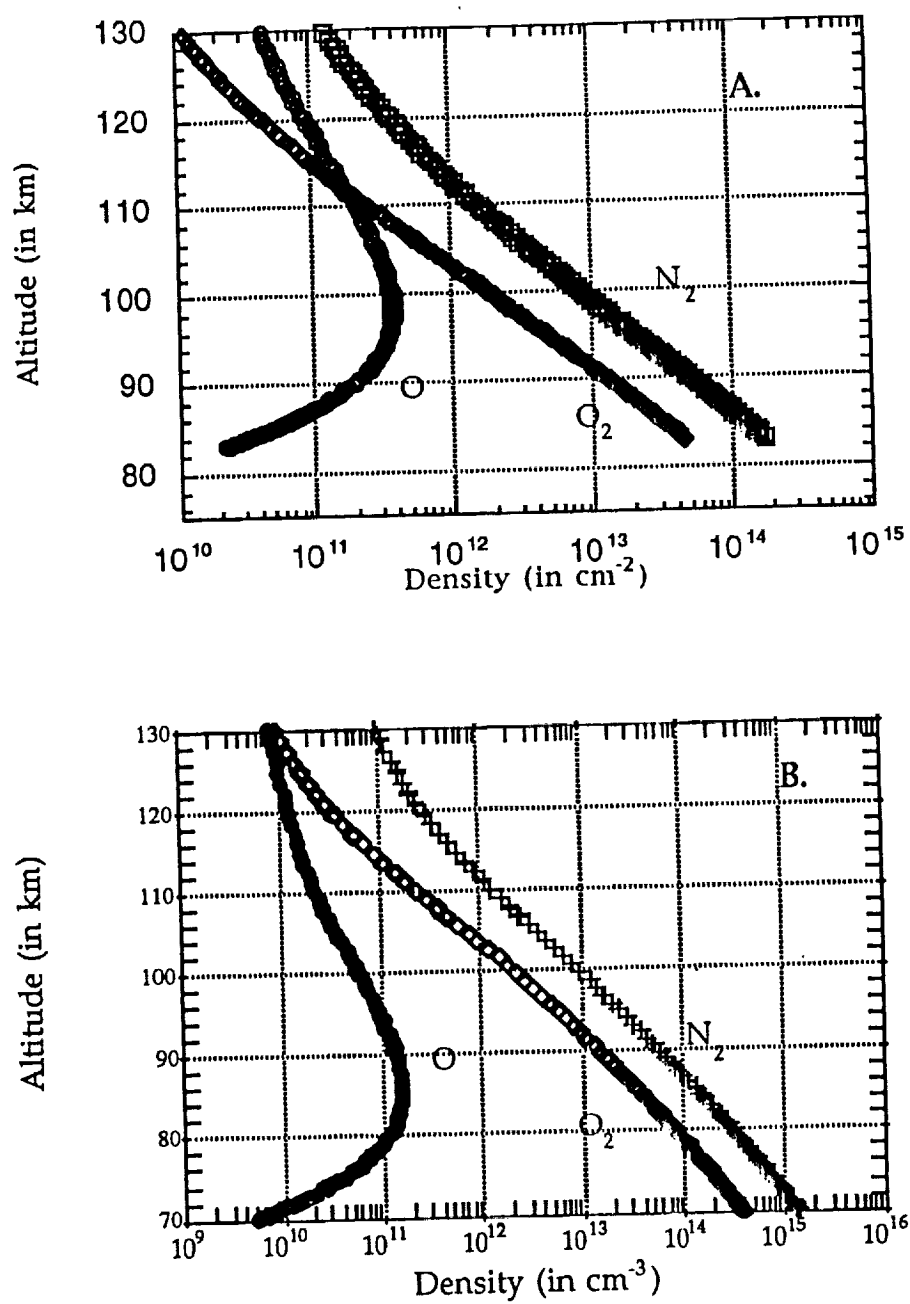
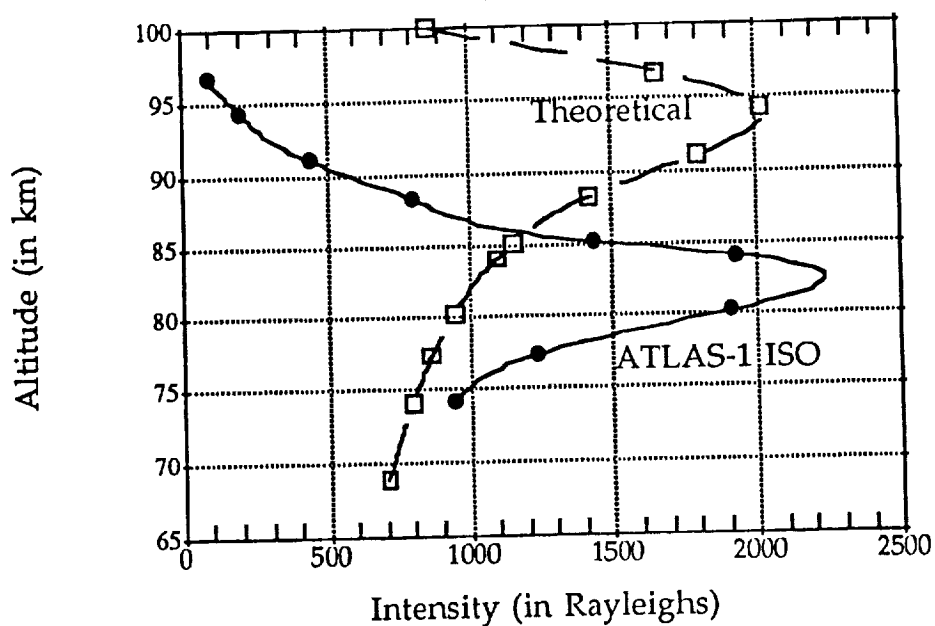


Figure 3 Movement of the Herzberg I emission layer with the variation of O and O<sub>2</sub> rate constants

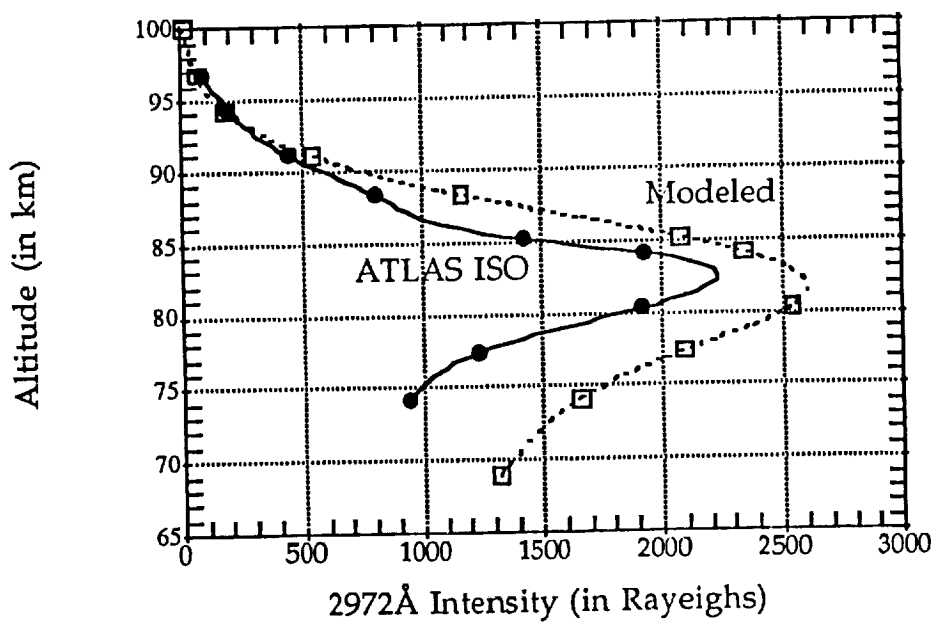
Fix caption



**Figure 4** The MSIS-90 atmosphere showing the constituents of interest in the mesopause. Plot A. shows the MSIS-90 atmosphere, the while B. depicts the atomic oxygen concentration shifted downward by 11 km.



**Figure 5** Modeled 2972Å intensity versus altitude with no shift in the MSIS-90 atomic oxygen concentration. Note the large altitude excursion of the modeled curve from the ATLAS-1 ISO data.



**Figure 6** Intensity versus altitude for 2972Å with atomic oxygen adjusted downward 12 km.

The peak height of the green line emission has been found to vary from 81 to 98 km in the ISO data. This is a radical departure from the previously published fixed altitude of 98 km. Confirmation of this finding was presented at the 1993 CEDAR conference in Boulder, Colorado. During this meeting, it was learned that the ATLAS AEPI group recorded an altitude of 85 km for the green line emission layer. These altitudes are believed to be correct since the AEPI's field of view contained stars whose position is well known. Also, Dr. Gordon Shepard, principle investigator of the URAS WINDII, showed evidence of altitude variation of 5577Å which occurred on a world wide scale.

A second discovery of this analysis was the apparent shape dependence of the emission layer on the atomic oxygen layer. Consider, for instance, the equation representing the concentration of a particular species,  $O_2^*$ , formed through the three body reaction.

$$[O_2^*] = \frac{\beta k_a [O]^2 [M]}{k_b [O] + k_c [O_2] + A} \quad (\text{eqn 1})$$

where  $k_a$ ,  $k_b$ , and  $k_c$  represent quenching constants for accompanying species,  $A$  is the radiative loss, and  $\beta$  the efficiency of the three body recombination reaction.

Consider the case when  $O_2$  quenching dominates the loss processes in equation 1, making the  $[O]$  and  $A$  terms negligible and leaving equation 2. This is the case for the  $O_2(A^3\Sigma)$ , see figure 7.

$$[O_2^*] = \frac{\beta k_a [O]^2 [M]}{k_c [O_2]} \quad (\text{eqn 2})$$

Since the  $N_2$  and  $O_2$  concentrations are similar within this region of the atmosphere (see plot of figure 3B.)  $M$ , the molecular constituent, may be considered to be

$$[M] = (\text{constant}) \cdot [O_2]. \quad (\text{eqn 3})$$

This simplifies the expression in equation 2 further and gives

$$[O_2^*] = \beta k_a [O]^2 \quad (\text{eqn 4})$$

which states that the  $O$  concentration in some state  $*$  is proportional to the square of the atomic oxygen concentration.



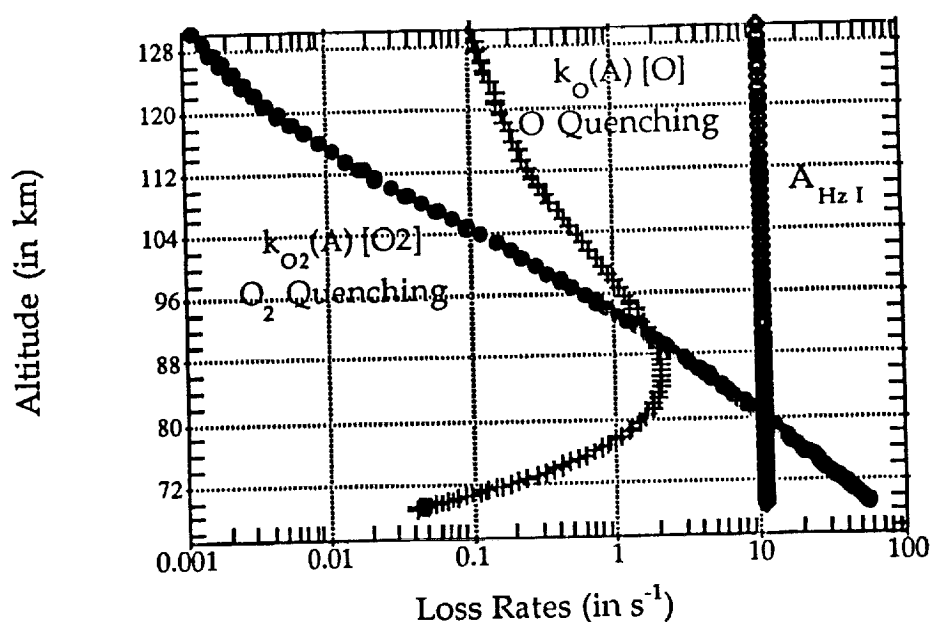


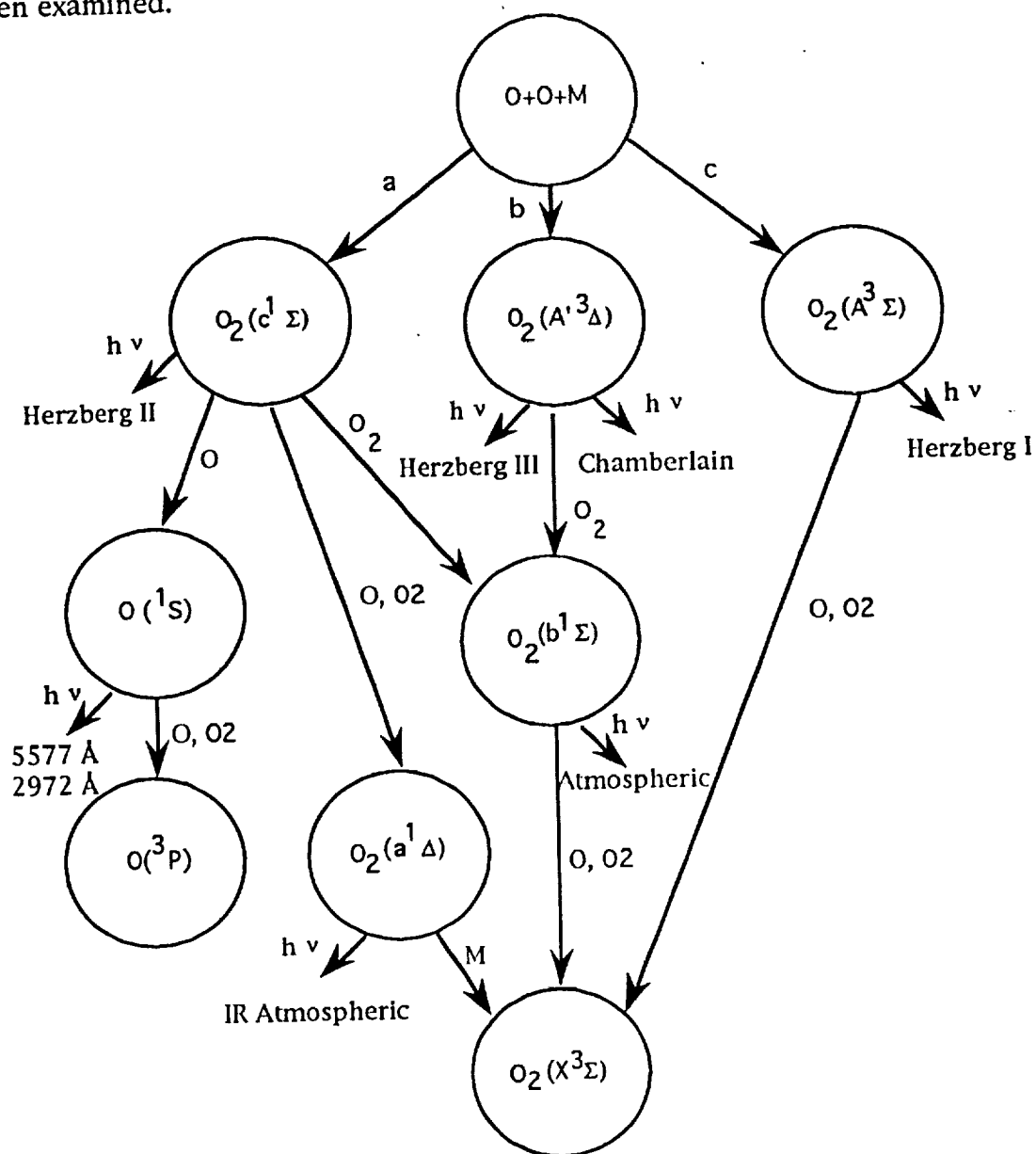
Figure 7 Loss frequencies for the  $O_2(A^3\Sigma^-)$  state.

Prior to my departure from Huntsville this summer, work was begun on the addition of vibrational quenching similar in manner to that used by Lopez-Gonzales, 1992, on the Herzberg II model. When this modification is complete, it will account for the vibrational de excitation and radiation of each of the molecular levels from  $v = 10$  and down. This is important for the  $O(^1S)$  case because as the model is currently written, production occurs directly into the  $O_2(c^1\Sigma)$  ground state, theoretically inaccurate since the  $v = 0$  level resides at a lower energy than  $O(^1S)$ . Once the vibrational level corrections have been implemented, the next task will be to test the model by attempting to fit a high altitude, wide profile data curve. A test of the precursor of  $O(^1S)$  will be necessary, when this is complete. This will be accomplished by making both the  $O_2(A^3\Sigma)$  and  $O_2(A^3\Delta)$ , in turn, the parent state of  $O(^1S)$ , and comparing the resulting intensities against the ISO data (see figure 8). With this method, we hope to validate the chemistry put forth by Bates, 1992. With the chemistry confirmed and all of the corrections in place, the code will be inverted to produce atomic and molecular oxygen concentrations as well as rate constants, given the intensity of the emission under observation. To verify this process it would be interesting to model a rocket borne photometer data set taken previously and published in the literature. Finally, the question of what is driving the atomic oxygen layer through its motions in the MLT region should be studied. This examination is though independent of the modeling process.

Publications and Presentations resulting from this work

Presently, this work has generated an abstract and presentation for the Fall 1993 AGU meeting in San Francisco, California. Also planned is an article to be

submitted to GRL which will be followed by a JGR article when the details have been examined.



**Figure 8** The chemistry of oxygen in the nighttime mesosphere lower thermosphere (MLT) region.

**Title : Thermosphere - Ionosphere Coupling :  
Neutral Wind to hmF2 Relation**  
**Author : Fanghwa(Grace) Chiu**  
**Major Advisor : Dr. Hamid Rassoul**

## **ABSTRACT**

The measurement of upper atmospheric neutral winds is valuable in many studies of the earth's ionosphere-thermosphere. The neutral wind affects many of the observable quantities and physical processes of the ionosphere, including the density profile of the ionospheric F region and the generation/maintenance of ionospheric electric fields. Wind measurements on a global scale are difficult to make, and the existing data base is sparse, especially in the southern hemisphere [Hedin et al, 1991]. Miller [1986,1989] presented a new technique of determining meridional thermospheric winds from measurements of the height of the maximum electron density in the F2 layer (hmF2). The technique is based on the approximately linear relationship between changes of neutral wind speed (U) and variation of the peak height of F2 layer (hmF2). The relationship can be written as  $\Delta h = \alpha \Delta U$  where  $\alpha$  is a constant for a given site at a given time. However,  $\alpha$  is expected to change with latitude, season, solar activity (F10.7 dependency), and geomagnetic activity (Ap dependency). The purpose of our study is to investigate variations of  $\alpha$  with each of the above geophysical parameters. We use different sets of geophysical parameters, the International Reference Ionosphere (IRI) model, and Field Line Interhemispheric Plasma (FLIP) model to calculate  $\alpha$  parameter, and return neutral winds. We employ the Factorial Designs method to analyze the dependency of  $\alpha$  on combinations of changes. Here, a preliminary result of this investigation is presented. It shows the dependence of  $\alpha$  and the interaction between variables. The main goal is to parametrize the  $\alpha$  parameter, so one can study variations of the upper atmospheric winds on a global scale using the Miller's technique or a similar method.

**Date:** 30 August 1993  
**From:** Jutta Baerman  
**To:** Dr. Rassoul  
**Subject:** Summer 1993 Report

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During the eight week period of the Summer quarter 1993 I accomplished the following tasks:

1. Read the following papers to get familiar with the research topic:
  - Heikkila's Mechanism for Impulsive Plasma Transport Through the Magnetopause: A Reexamination, *C. J. Owen and S.W.H. Vowley*, JGR, Vol 96, No. A4, P. 5565-5574
  - Comment on Owen and Cowley's Analysis of Impulsive Plasma Transport Through the Magnetopause, *Walter J. Heikkila*, JGR, Vol 97, No. A2, P. 1639
  - Magnetic Field Reconnection, *W. I. Axford*
  - Magnetic Field Reconnection at the Magnetopause: An Overview, *B.U.O. Sonnerup*,
  - ISEE-1 and 2 Magnetometer Observations of the Magnetopause, *R. C. Elphic and C. T. Russell*, Proceedings of Magnetospheric Boundary Layers Conference, Alpbach, 11-15 June 1979 (ESA SP-148, August 1979)
  - The Magnetic Mirror Force in Plasma Fluid Models, *R. H. Comfort*, AGU 1988
  - The Evolution of Arguments Regarding the Existence of Field-Aligned Currents, *A. J. Dessler*
  - Coordinated Ground and Satellite Observations of Conductivities, Electric Fields, and Field-Aligned Currents, *R. M. Robinson*
  - Field Aligned Currents Near the Magnetosphere Boundary, *Edward W. Hones, Jr.*
  - Implications of the 1100 UT March 22, 1979 CDAW 6 Substorm Event for the Role of Magnetic Reconnection in the Geomagnetic Tail, *T. A. Fritz and D. N. Baker, R. L. McPherron, W. Lennartsson*

- IMP 6 Observations of the Plasma Boundary Layer, *T. E. Eastman, E. W. Hones, Jr.*, Proceedings of Magnetospheric Boundary Layers Conference, Alpach, 11-15 June 1979 (ESA SP-148, August 1979)

## 2. Processed IMP-8 Magnetometer data:

- Updated the program PLOTIMP.FOR to read electronically transferred data: (Copy of source code available upon request)
  - included error checks for nonexistent files, check for last day of the month, leap year distinction,
  - wrote subroutine to read the datafile for the next day if the date span given by the command file required it
- Ran program for 3 months covering Jan 1 - Mar 31, 1983 in 10 day intervals using customized command files
- Created data files containing magnetic field data in GSE and GSM coordinates, magnitude of B as well as data files containing satellite position data in the same coordinates.
- Transferred data from the VAX to Kaleidagraph spread sheets.
- Calculated magnetic latitude and longitude in GSM coordinated for all 10 day intervals, and in GSE coordinates for 1 or 2 intervals??
- Plotted graphs of magnitude of B, GSM coordinates of B, latitude and longitude as well as GSE position coordinates versus UT in one staggered plot (this required the use of the Quadra in Dr. Blatt's lab since the II-SI in the JOVE lab does not have enough RAM to handle the large number of data points involved) A sample plot is attached to this report.
- Plotted graphs showing the orbital motion of the IMP-8 satellite for the 10-day intervals modeled after *IMP 8 (Explorer 50) Trajectory October 30, 1973 to November 9, 1980* by Sullivan et al. (A sample of these graphs is also attached)

**Note:** The tasks mentioned above on data processing sound very simple; however, with the limited computer facilities available they turned out to be extremely time consuming. The limited storage space on the Macs created another problem, especially since the graphs contain alot of data points and require a minimum of 1 MB of memory each. Therefore, the graphs had to be transferred to magnetic tape via the schools VAX computer.

3. Studied Chapters 1-4 of George K. Parks's *Physics of Space Plasmas*:

- 1) Electrodynamics in Space
- 2) Equations and Definitions
- 3) Electromagnetic Fields in Space
- 4) Particles in Space

4. Completed the course Applied Complex Variables with the grade A.

The course was based on Chapters 1-8 of the book by Churchill and is very valuable for electromagnetic theory which is a major factor in my research.

5. Fulfilled other duties as assigned (such as acquiring copies of articles and books).

# B-Field and Position Data vs UT for Feb 10 through Feb 19, 1993

B-Magnitude

BXSM in nT

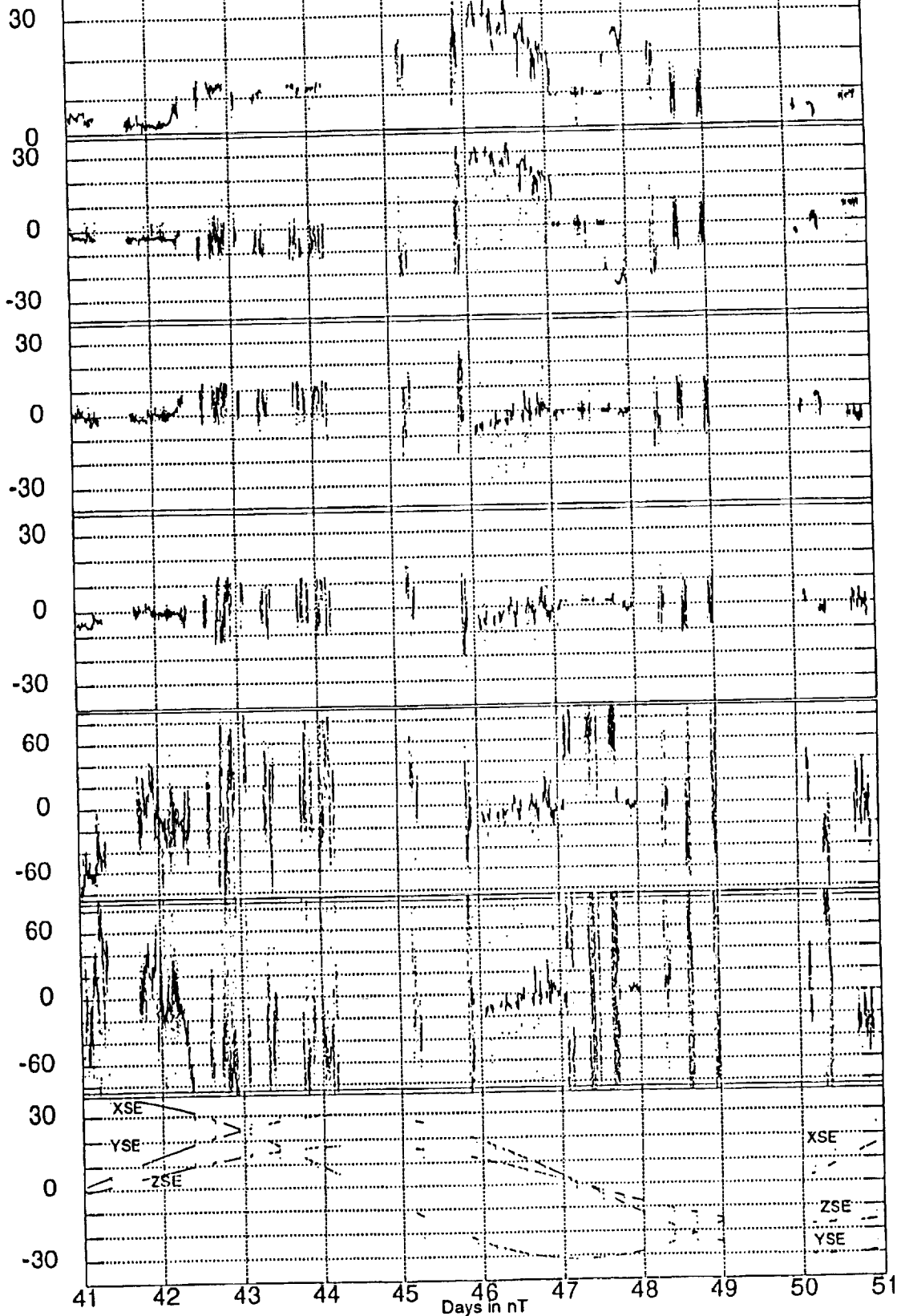
BYSM in nT

BZSM in nT

Latitude (GSM)

Longitude (GSM)

XSE, YSE, ZSE in  $R_E$



# B-Field and Position Data vs UT for Feb 10 through Feb 19, 1993

B-Magnitude

BXSE in nT

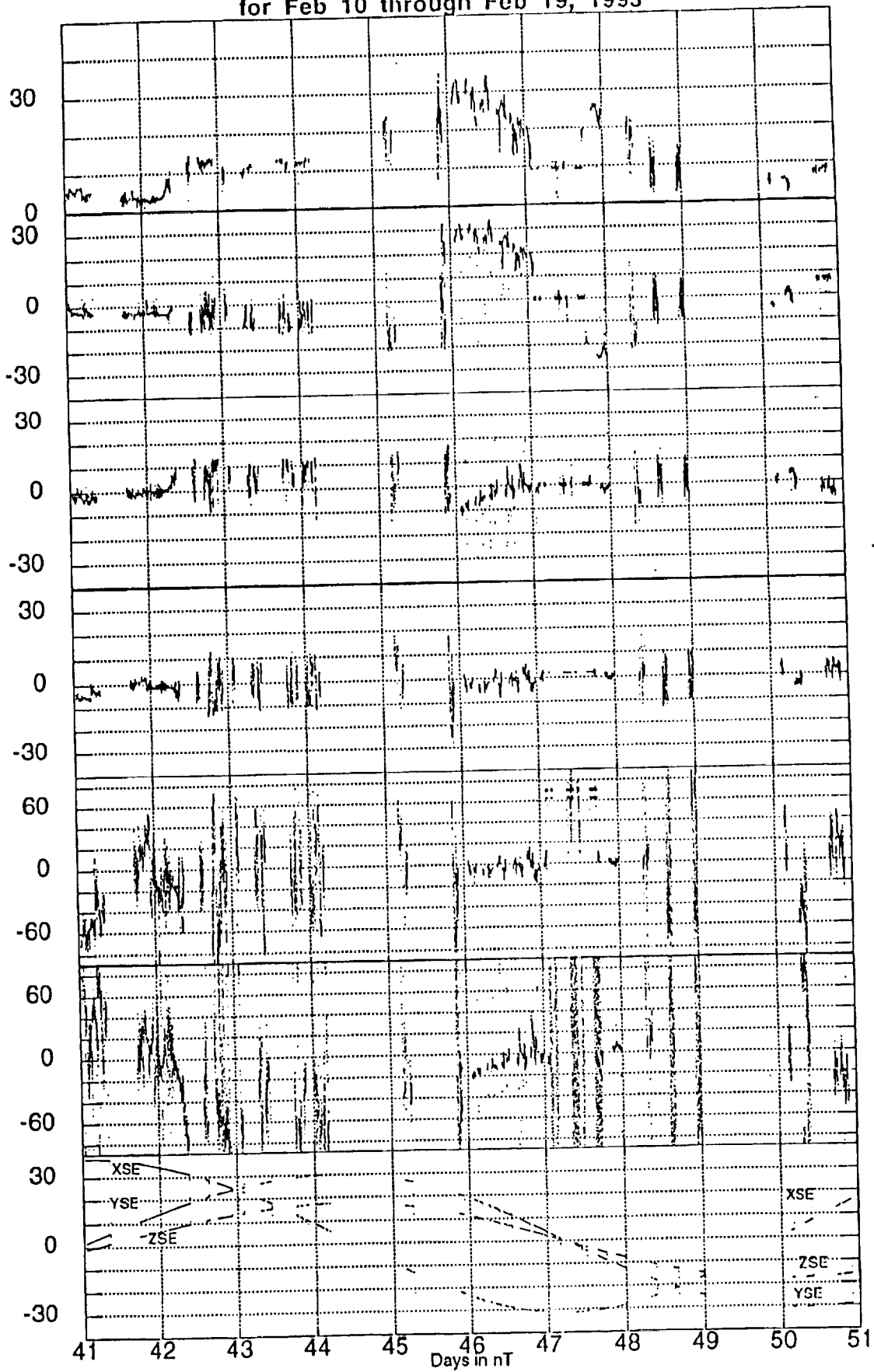
BYSE in nT

BZSE in nT

Latitude (GSE)

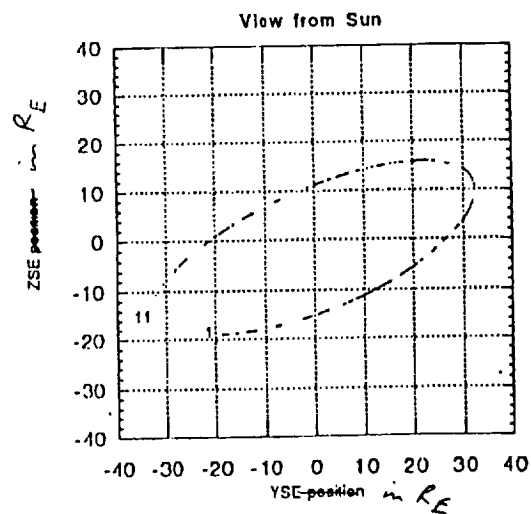
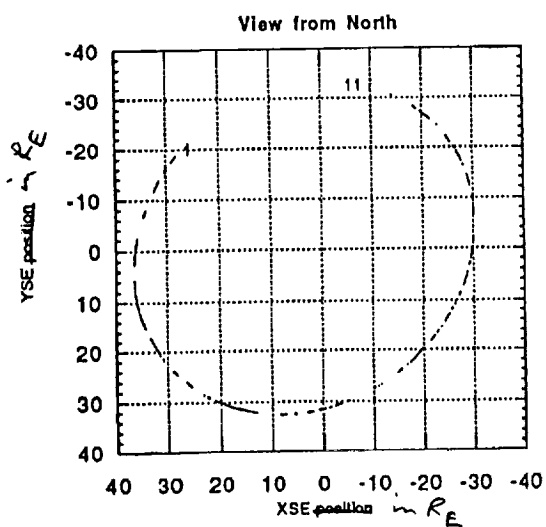
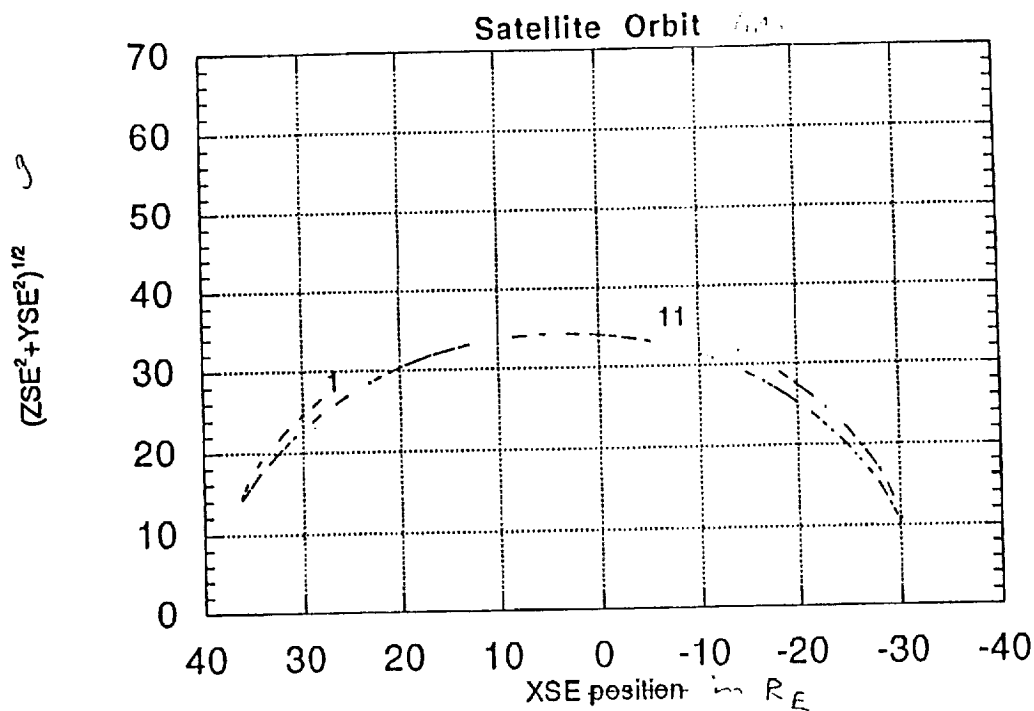
Longitude (GSE)

XSE, YSE, ZSE in  $R_E$



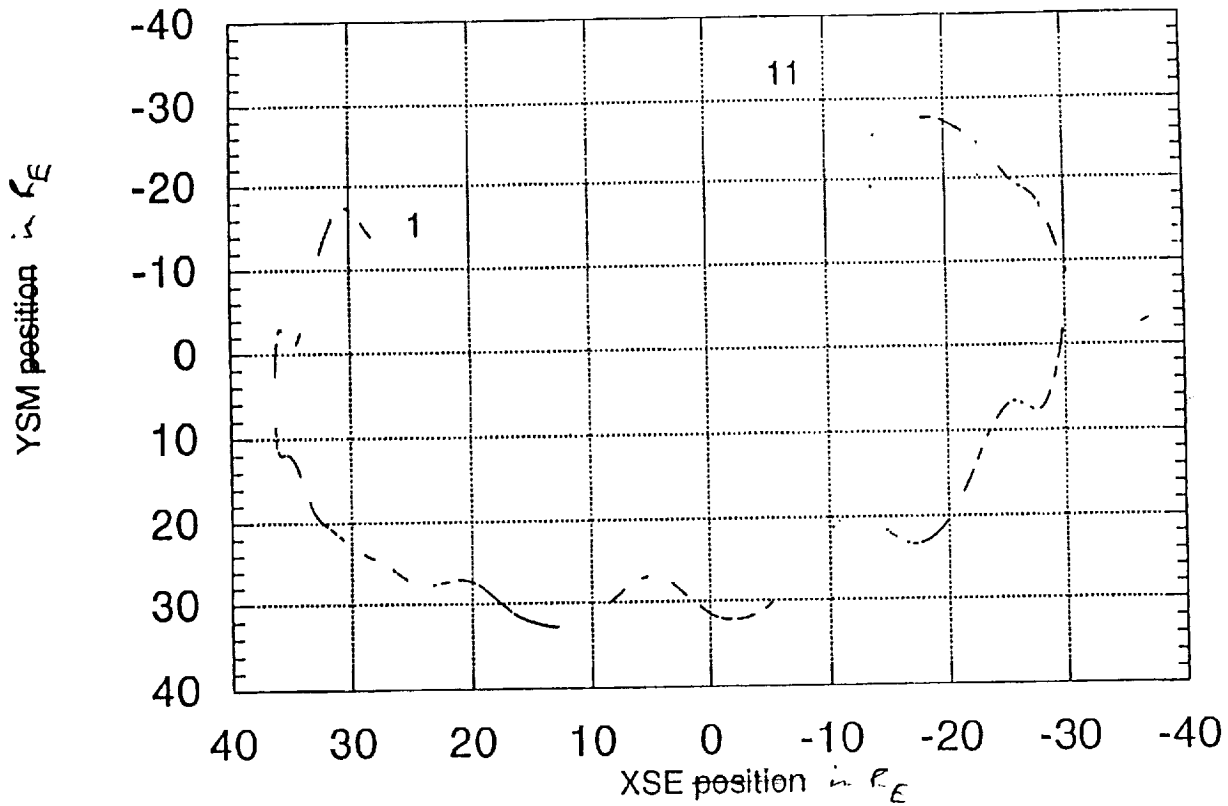


IMP 8 Trajectory,  
from Jan 1 through Jan 10, 1983  
(Days 1 through 10)

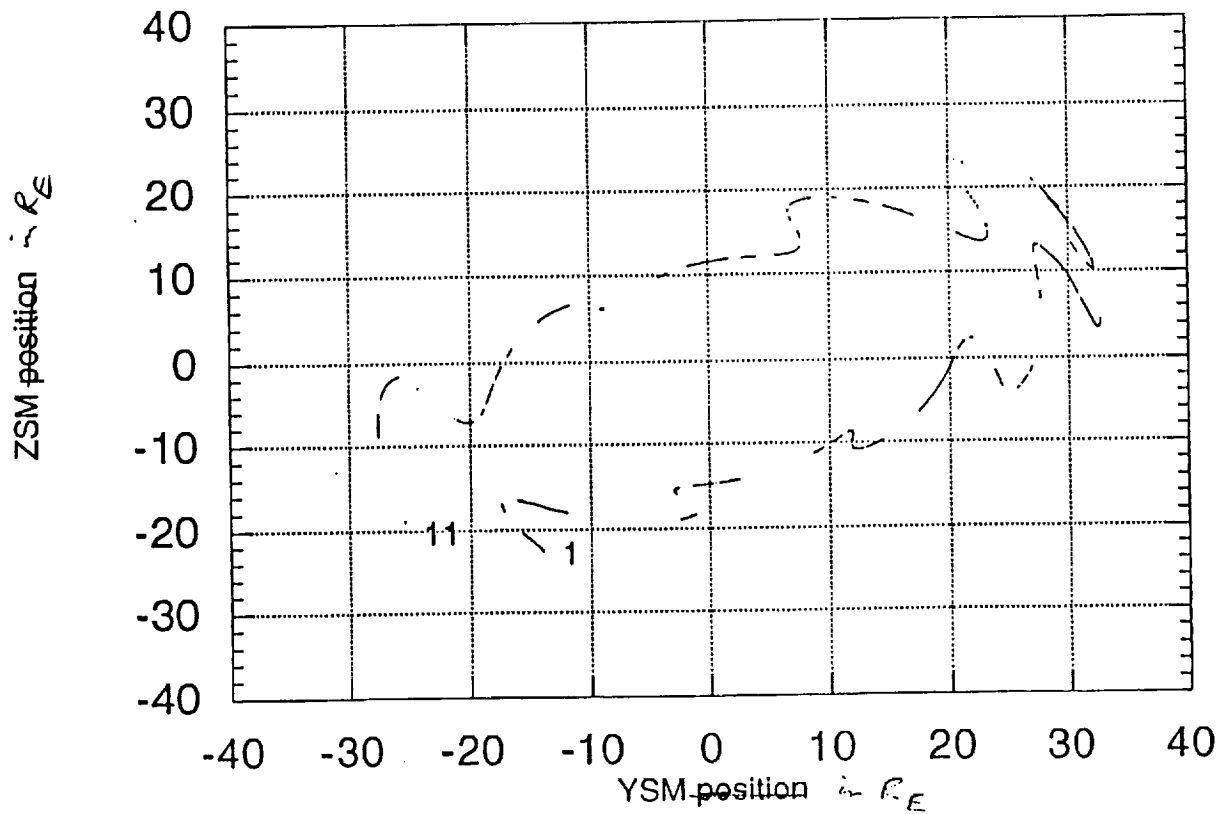


IMP 8 from Jan 1 through Jan 10, 1983 14

View from North



View from Sun



# SYLLABUS

## FALL SEMESTER 1993

SPS 5020 - 01 Space Physics 1

INSTRUCTOR: Dr. Hamid K. Rassoul  
 OFFICE: Crawford Science Tower, Room 423 B  
 OFFICE HOURS: Monday-Thursday 2:00-3:00 pm  
                   OR any other time by appointment  
 PHONE: 768-8000, ext. 8778  
 Classroom/Class time : Q15/Mon,Wed 03:00 - 04:20 pm  
 REQUIRED TEXT: R1: PHYSICS of SPACE PLASMAS: An Introduction (2nd prints)  
                   by George K. Parks; Addison-Wesley Publ. Company, 1991.

OTHER (TEXT) REFERENCES:

- R2: Introduction to Plasma Physics and Controlled Fusion by F.F. Chen
- R3: The Solar-Terrestrial Environment by J.K. Hargreaves
- R4: The earth's Ionosphere, M.C. Kelly
- R5: Electromagnetic Fields and waves; Lorrain-Corson-Lorrain
- R6: Classical Electrodynamics; Jackson

Tentative Outline:

WEEK	TOPIC	Main Source(s)
1 - 2	Basic Structures of Field and Plasma	Chp 1 & R2: Chp 1 and Class notes
3	Max/Lor. Eqs; Inhom. field & Plasma	Chps 2 and 3
4 - 5	Single Particle Motion	Chp 4 & R2: Chp 2
6 - 7	MHD equations and concepts	Chp 5 and R2: Chp 3
8	Plasma Convections & Mid term	Chp 6
9 - 10	Currents in Space	Chp 7
10 - 12	Boundaries in Space	Chps 8 and 11
13 - 15	Waves and Shocks	Chps 9 and 10

Your final grade will be determined from the following:

Quizzes: Every other week; 1st one will be given on Sep 8 ; 15 minutes	10%
Projects: (i) a review article about a Space Plasma issue relevant to the course materials; (ii) an investigating computer project that utilizes a magnetospheric satellite database.	10%
Homework: 7-8 sets; about 5 problems per set; due one week after assigned; some homework are reading and reporting assignments.	10%
Mid-Term Exam (Wednesday, October 20, 1993)	20%
Final Exam (Monday, December 13, 1993, 01:00-03:00 p.m.)	50%
No Curve for "A" mark.	

Welcome Aboard !